University of Piraeus,

Dept. of International and European Studies,

M.Sc. in Energy: Strategy, Law & Economics

The Greek Biofuel market: Trends, prospects and challenges

Michael N. Fotiadis

Thesis Advisor:

Dr. Michael Polemis

ΔΗΛΩΣΗ ΓΡΑΦΟΝΤΑ

Ο υπογράφων Φωτιάδης Μιχαήλ βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

Dedicated to Sofia and our growing family

Acknowledgements

I would like to express my deep appreciation to the following people:

My thesis advisor, Assistant Professor in the Department of Economics at the University of Piraeus, **Dr. Michael Polemis** for his time, guidance and encouragement. His genuine support amplified with the extensive research and numerous publications he has performed and tirelessly keeps enriching, really assisted me with ideas and tools so as to complete this thesis. Working with you has been an exciting experience.

Dr. Nikolaos Farantouris, Professor at the International European Studies Department, University of Piraeus, holder of the Jean Monnet Chair on EU Law and Policies (Competition, Energy and Transport) and Director of the Master Program in "Energy: Strategy, Law & Economics" at the Department of International & European Studies of the University of Piraeus, Greece, in the context of which this study was conducted. Thank you for your inspiration, support and innovative ideas.

I also thank my father Teacher **Nestor Fotiadis** for his invaluable and affluent help in the linguistics and editing of this thesis.

Finally, I dedicate this thesis to my special wife **Sofia**, to whom I could not possibly be more thankful, for all her vigorous support throughout the attendance of this Master Program. Moreover, I deeply thank her for the tangible assistance on the empirical part of this study, her scientific expertise and more importantly her loving kindness.

Athens, July 2016

Table of Contents

List of Tables:

List of Figures:

Chapter 1: Introduction & Global Outlook

1.1 Biofuels in general

The huge increase in oil and other fuel prices over the last few years and a concern that we have reached (or will soon reach) peak oil – after which oil extraction begins to decrease – have renewed the interest in alternative sources of energy. These include solar, wind, ocean wave and tidal flow, geothermal, and biofuels which at their initial outbreak were considered as the society's liberator from liquid fossil fuels. However, long disputes regarding the biofuel viability, enriched with high controversy about their actual sustainability, positive and negative effects to the society and so on, have been challenging their acceptance globally from time to time.

In general, the alternative energy sources are attractive because they can be developed and used without questioning the very workings of the economic system. Although oil prices may come down as they have since mid-2014 until nowadays, they are likely to return and remain at high levels as the reserves of easily recovered oil and gas relative to annual usage continues to decline.

The use of biological materials – coming from recently living plants – as fuels has a long history. Many a night did early humans sit around a wood fire to cook food, keep warm, and protect themselves from predators. Today wood is still used as a fuel source in some countries, dried cow manure is collected in India for that purpose as well, and crop residues in many parts of the world are used for cooking and/or heating. In addition, the natural gas (methane) produced from small-scale liquid manure (animal and human) systems has been used for years in China and India for lighting, heating, and cooking. Moreover, for decades, sewage treatment plants in northern climates have used natural gas produced during the treatment process to heat the vat during the cold seasons, to increase efficiency of the microorganisms in the plant or to produce electricity.

The idea behind biofuels is simple. Plants capture the energy of the sun and produce substances – sugars, starch, oils, and cellulose - that can be harvested and then converted into sources of energy for us to use. Growing plants to produce fuel is supposed to be more ecologically sound because – in contrast to diesel oil and gasoline which add new carbon dioxide to the atmosphere when burned – when biofuel energy is used, the carbon dioxide that returns to the atmosphere is simply that which had recently been captured by plants during their lifetime cycle.[1]

[1] Magdoff, A., (2008), The Political Economy and Ecology of Biofuels, Monthly Review: An Independent Socialist Magazine, Vol. 60, Issue 03, p. 34 – 35, New York, USA

1.1.1 Typology & Technology

Also known as agrofuels, biofuels are mainly derived from biomass or bio waste. These fuels can be used for any purposes, but their main utilization should be in the transportation sector. Most vehicles require fuels which provide high power and are dense so that storage is easier. These engines require fuels that are clean and in the liquid form.

The most important advantage of using liquid as fuel is that they can be easily pumped and can also be handled easily. This is the main reason why almost all vehicles use liquid form of fuels for combustion. For other forms of non-transportation applications there are other alternative solid biomass fuels like wood. These non-transportation applications can bring into use these solid biomass fuels as they can easily bear the low power density of external combustion.

Biofuels, like fossil fuels, come in a number of forms and meet a number of different energy needs. The class of biofuels is subdivided into two generations, which will be elaborated further below.

Table 1. Biofuels

This table breaks biofuels down by generation and then explores their uses, energy densities, and greenhouse gas impacts.

Fuel	Feedstock	Energy Density (megajoules/kilogram)	Greenhouse Gas CO_2(kg/kg)	Notes
First Generation				
Bioalcohol	Starches from wheat, corn, sugar cane, molasses, potatoes, other fruits	By Type	By Type	
Ethanol		30	1.91	
Propanol		34	N/A	
Butanol		36.6	2.37	
Biodiesel	Oils and fats including animal fats, vegetable oils, nut oils, hemp, and algae	37.8	2.85	
Green Diesel	Made from hydrocracking oil and fat	48.1	3.4	Chemically identical to fossil fuel

	feedstock			diesel
Vegetable Oil **Castor Oil** **Olive Oil** **Fat** **Sunflower Oil**	Unmodified or slightly modified	By Type 39.5 39 32 40	By Type 2.7 2.8 N/A 2.8	
Bioethers	Dehydration of alcohols	N/A	N/A	These are additives to other fuels that increase performance and decrease emissions, particularly ozone
Biogas	Methane made from waste crop material through anaerobic digestion or bacteria	55	2.74 (does not take into account the direct effect of methane, which is 23X more effective as a GHG than CO_2	Same properties as methane from fossil fuels
Solid Biofuels **Wood** **Dried plants** **Bagasse** **Manure** **Seeds**	Everything from wood and sawdust to garbage, agricultural waste, manure	By Type 16-21 10-16 10 10-15 15	By Type 1.9 1.8 1.3 N/A N/A	This category includes a very wide variety of materials. Manure has low CO_2, but high nitrate emissions.
Second Generation				
Cellulosic ethanol	Usually made from wood, grass, or inedible parts of plants			
Algae - based	Multiple	Can be used to	See specific	More

biofuels	different fuels made from algae	produce any of the fuels above, as well as jet fuel	fuels above	expensive, but may yield 10-100X more fuel per unit area than other biofuels
Biohydrogen	Made from algae breaking down water.	Hydrogen compressed to 700 times atmospheric pressure has energy density of 123	Does not have any greenhouse effect.	Used in place of the hydrogen produced from fossil fuels
Methanol	Inedible plant matter	19.7	1.37	More toxic and less energy dense than ethanol
Dimethylfuran	Made from fructose found in fruits and some vegetables	33.7		Energy density close to that of gasoline. Toxic to respiratory tract and nervous system
Fischer-Tropsch Biodiesel	Waste from paper and pulp manufacturing	37.8	2.85	Process is just an elaborate chemical reaction that makes hydrocarbon from carbon monoxide and hydrogen

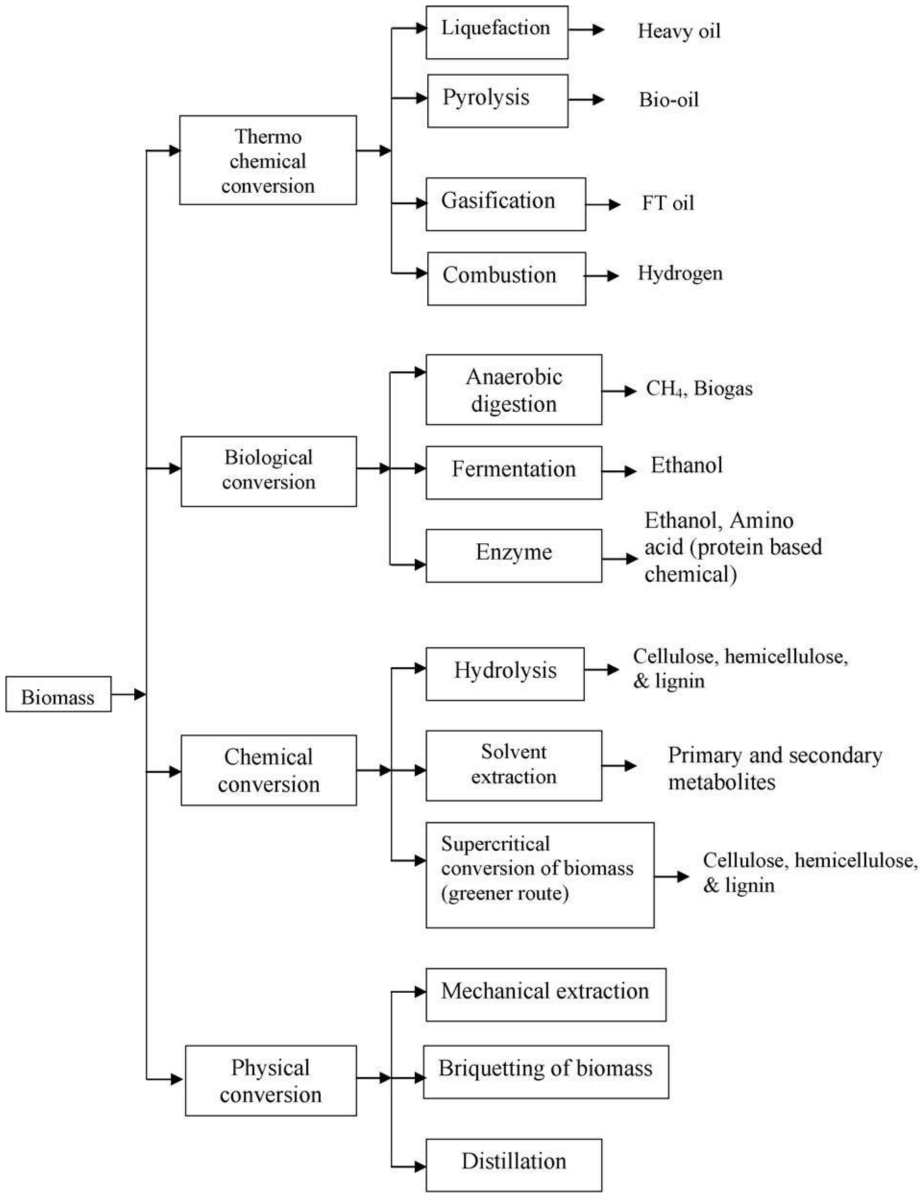
Source: http://biofuel.org.uk/what-are-biofuels.html

First generation biofuels[2]

The dramatic rise in oil prices seen in the last decade has also enabled liquid biofuels to become cost-competitive with petroleum-based transportation fuels, and this has led to a surge in research and production around the world. The three main types of first generation biofuels used commercially are biodiesel (bio-esters), ethanol, and biogas of which large quantities have been produced worldwide so far and for which the production process is considered 'established technology'. Biodiesel is a substitute of diesel and is produced through transesterification of vegetable, residual oils and fats, with minor engine modifications; it can serve as a full substitute as well. Bioethanol is a substitute of gasoline and it is a full substitute for gasoline in so-called flexi-fuel vehicles. It is derived from sugar or starch through fermentation. Bioethanol can also serve as feedstock for ethyl tertiary butyl ether (ETBE) which blends more easily with gasoline. Biogas, or biomethane, is a fuel that can be used in gasoline vehicles with slight adaptations. It can be produced through anaerobic digestion of liquid manure and other digestible feed-stock. At present, biodiesel, bioethanol and biogas are produced from commodities that are also used for food.

[2] Naik, S.N. et al (2010), Production of first and second generation biofuels: A comprehensive review, Volume 12, Issue 2, p. 587 – 597, Elsevier, Amsterdam, The Netherlands

Figure 1. First generation biofuels conversion processes

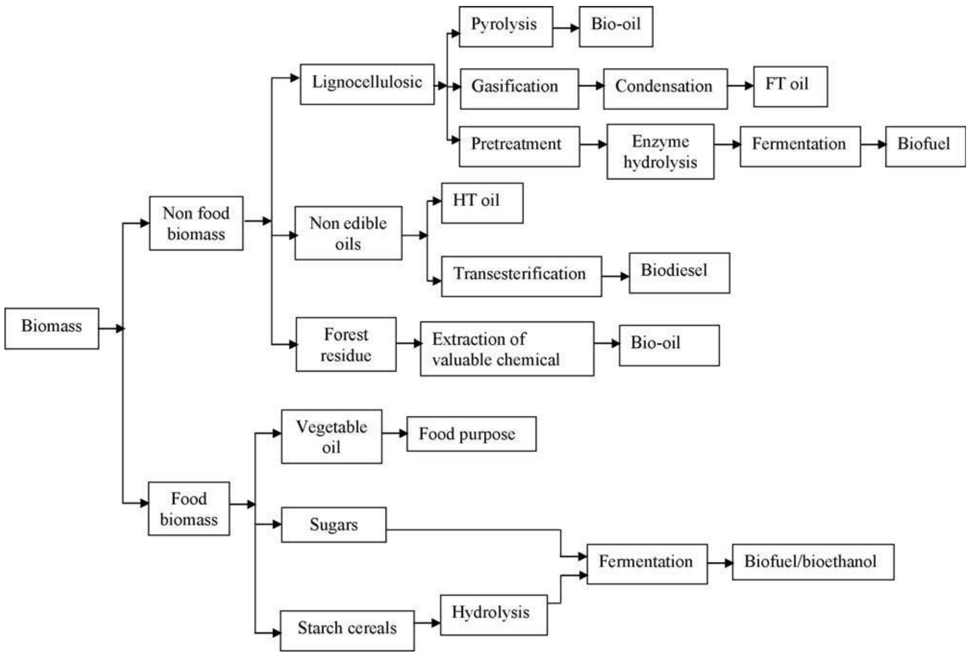


Source: Naik, S.N. et al (2010), Production of first and second generation biofuels: A comprehensive review, Volume 12, Issue 2, Elsevier, Amsterdam, The Netherlands

Second generation biofuels[3]

Second generation biofuels are produced from biomass in a more sustainable fashion, which is truly carbon neutral or even carbon negative in terms of its impact on CO2 concentrations. In the context of biofuel production, the term 'plant biomass' refers largely to lignocellulosic material as this makes up the majority of the cheap and abundant nonfood materials available from plants. At present, the production of such fuels is not cost-effective because there are a number of technical barriers that need to be overcome before their potential can be realized. Plant biomass represents one of the most abundant and underutilized biological resources on the planet, and is seen as a promising source of material for fuels and raw materials. As it is most basic, plant biomass can simply be burnt in order to produce heat and electricity. However, there is great potential in the use of plant biomass to produce liquid biofuels. Plant biomass is comprised mostly of plant cell walls, of which typically 75% is composed of polysaccharides. These polysaccharides represent a valuable pool of potential sugars, and even in traditional food crops such as wheat (Triticum aestivum) there is as much sugar tied up in the stems as there is in the starch of the grains. To date, the potential of many crop residues, such as straw and wood shavings, to provide sugar feedstocks for biofuel production has not been realized. However, biofuel production from agricultural by-products could only satisfy a proportion of the increasing demand for liquid fuels. This has generated great interest in making use of dedicated biomass crops as feedstock for biofuel production.

Figure 2. Second generation biofuels conversion processes



Source: Naik, S.N. et al (2010), Production of first and second generation biofuels: A comprehensive review, Volume 12, Issue 2, Elsevier, Amsterdam, The Netherlands

It is worth mentioning that according to other researchers and scholars, the exact criteria that apply in the labeling of first and second generation biofuels are not clearly defined, whereas a third generation of biofuels is introduced as well[3]. Biemans et al (2008)[4] classify biofuels as follows:

---

[3] Campbell, A. & Doswald, N., (2009), The impacts of biofuel production on biodiversity: A review of the current literature, UNEP-WCMC, Cambridge, UK

Table 2. Major biofuel sources. Adapted from Biemans et al. (2008)

1st Generation		***2nd Generation***	***3rd Generation***
Biodiesel	**Bioethanol**		
Palm oil Rape seed Sunflowers Soy beans Jatropha	Corn Sugar cane Sugar beets Wheat	Willows Poplars Grass Agricultural waste products Forestry waste products	Algae

__Source:__ Campbell, A. & Doswald, N., (2009), The impacts of biofuel production on biodiversity: A review of the current literature, p. 6, UNEP-WCMC, Cambridge, UK

1.1.2 Contribution & Question

Over the last two decades, there has been a continuous long standing worldwide debate over the biofuels' positive and negative impacts. The main argument of the advocates of biofuels' positive contribution is the reduction of the emissions of gases producing the greenhouse effect, particularly CO2 emissions. This is because organisms (that biomass comes from) during their lives absorb CO2 equal to the amount emitted when biomass (or biofuel produced from it) is burned[5]. At the other side of the spectrum those who are opposed to their usefulness and positive effects claim among other, that the biofuels production in general, deprives land crops from food production, causing food prices to increase and therefore endangers poor peoples' food security. The latter argument has been commonly addressed as the "Fuel vs. Food" debate[6].

For almost every positive effect of biofuels, there lies a negative one too. According to recent literature, most scholars seem to conclude that the issue of biofuels pros and cons should be addressed both locally and globally and of course in the short and long term[7]. Each country or region has different own resources (land, waters, ecosystem etc.), uses more or less advanced technology in its biofuels industry[8], has more or less to gain from biofuels, in terms of energy security or/and independence and therefore applies a different policy mix towards biofuels development. (However, EU countries do have differences over the previous factors

[4] Biemans, M., Waarts, Y., Nieto, A., Goba, V., Jones-Walters, L. & Zöckler, C., (2008), Impacts of biofuel production on biodiversity in Europe, ECNC-European Centre for Nature Conservation, Tilburg, the Netherlands

[5] Petrou, C. and Pappis, C., (2008), Biofuels: A Survey on Pros and Cons, Energy and Fuels, 23, p. 1055-1066, Piraeus

[6] Hamenlick, C., (2013), Biofuels and Food Security: Risks and opportunities, Ecofys, Chamber of Commerce 30161191, p. 1-2, Utrecht

[7] HLPE (2013), Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, p. 107, Rome, Italy

[8] HLPE (2013), Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, p. 43-47, Rome, Italy

between them, but ought to follow similar policies in order to accomplish the same targets - this paradox will be tackled in a later section).

Pros

First of all, unlike fossil fuels, biofuels are a renewable energy source. Because they are derived from crops that can be harvested annually, or in the case of algae monthly, biofuels are theoretically unlimited. Undoubtedly, there are certain restrictions, the threat to the food supply being the major one. Thus, their availability and renewability is a key driver of their development globally. As mentioned above, CO_2 emissions producing the greenhouse effect can be reduced, since biomass has absorbed during its life equal quantity of CO_2 to the amount emitted when burned, provided that it (the biomass) is entirely renewed and that cut and renewed biomass absorb equal amounts of $CO_{2.}$ The SO_2 emissions can be reduced too, since the content of biomass in sulfur is much lower compared to conventional fossil fuels[9]. Another key advantage of biofuels is the potentially reduced dependence on foreign oil and consequent savings on energy expenditure that could instead be invested in other development activities. Biofuel production thereby helps boost a country's energy security. Furthermore, the potential of biofuel production to strengthen small scale local economies and promote rural development is irrefutable. The diversification of agriculture, if properly and strategically planned, may attract investment and new technology to invigorate agriculture. Then, the establishment of biomass processing plants which follows consequentially can create job opportunities resulting into increased household income and improved welfare[10].

Cons

As stated in the comprehensive work of Evangelos C. Petrou and Costas P. Pappis (2008) and other researchers, the mass production of biofuels can lead to the increase of greenhouse effect gases (GHGs), since significant use of fossil transportation fuels takes place throughout the complex logistics chain starting from the biomass collection and transportation to processing plants, continuing with the biofuels production process and ending with their distribution to oil middle distillates refineries, other storage facilities, retail sites and elsewhere. The deforestation process of lands to be used for biomass cultivation also adds GHGs to the atmosphere (as well as SO_2 due to the consumption of fossil fuels). Another controversial item of the biofuels' effects agenda is the impacts on biodiversity: Such

[9] Petrou, C. and Pappis, C., (2008), Biofuels: A Survey on Pros and Cons, Energy and Fuels, 23, p. 1062-1063, Piraeus

[10] Sombilla, M., (2009), Integranting biofuel and rural renewable energy production in agriculture for poverty reduction in the Greater Mekong Subregion: an overview and strategic framework for biofuels development, Asian Development Bank, p. 3, Mandaluyong City, Philippines

impacts depend greatly on the type of crops that are planted and the previous land use. It is difficult to generalize the impact of 'biofuels', as each biofuel crop has its own set of advantages and costs. Some authors[11] claim that due to the potential loss of habitats, the direct conversion of natural ecosystems and indirect land use change to accommodate biofuel production is likely to be detrimental to biodiversity. On the other hand, plantations on marginal or degraded lands could have positive effects on biodiversity[12]. In general terms, biodiversity loss occurs when high biodiversity land is converted into plantations that contain lower levels of biodiversity. The impacts on biodiversity are therefore a function of the biodiversity present prior to land conversion, the biodiversity present after the land has been converted for biofuel feedstock production, and the 'off-farm' impacts of the biofuel feedstock plantations on the surrounding areas[13]. Reports have been submitted on various other environmental impact categories, such as the ozone layer depletion and acidification, dioxin emissions, heavy metals (Pb, Hg etc.) accumulation and contamination of surface water and soil, due to the intensive cultivation of energy crops which creates as well eutrophication and eco-toxicity[14]. Over the past fifteen years, the link between biofuels production and food prices has been studied at a great scale. The main reason triggering such enormous international interest was the biofuel production massive expansion, from less than 20 billion liters per year in 2001 to over 100 billion liters per year in 2011, which was supposedly connected to sharp rise in food commodity prices quickly accompanied by food riots in the cities of many developing countries[15]. While various researches in the last decade have implied or even evinced the connection between increasing demand for energy crops and increasing food prices, there have been others more recent that question directly the biofuels' real impact on food prices, mainly by a) pointing out the impacts of other causal factors, as summarized below and b) claiming that agricultural commodity prices are strongly linked to the oil price, the increase of which can be controlled by the development of alternative energy sources, such as the biofuels[16].

---

[11] GBEP (2008), A Review of the Current State of Bioenergy Development in G8 +5 Countries, Rome, Italy

[12] Eickhout, B., van den Born, G.J., Notenboom, J., van Oorschot, M., Ros, J.P.M., van Vuuren, D.P. & Westhoek, H.J., (2008), Local and global consequences of the EU renewable directive for biofuels. Testing the sustainability criteria. MNP report.

[13] Campbell, A. & Doswald, N., (2009), The impacts of biofuel production on biodiversity: A review of the current literature, UNEP-WCMC, Cambridge, UK

[14] Petrou, C. and Pappis, C., (2008), Biofuels: A Survey on Pros and Cons, Energy and Fuels, 23, p. 1064, Piraeus

[15] HLPE (2013), Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, p.55, Rome, Italy

[16] Hamenlick, C., (2013), Biofuels and Food Security: Risks and opportunities, Ecofys, Chamber of Commerce 30161191, p. iii, Utrecht

Table 3. Factors that increase food prices.

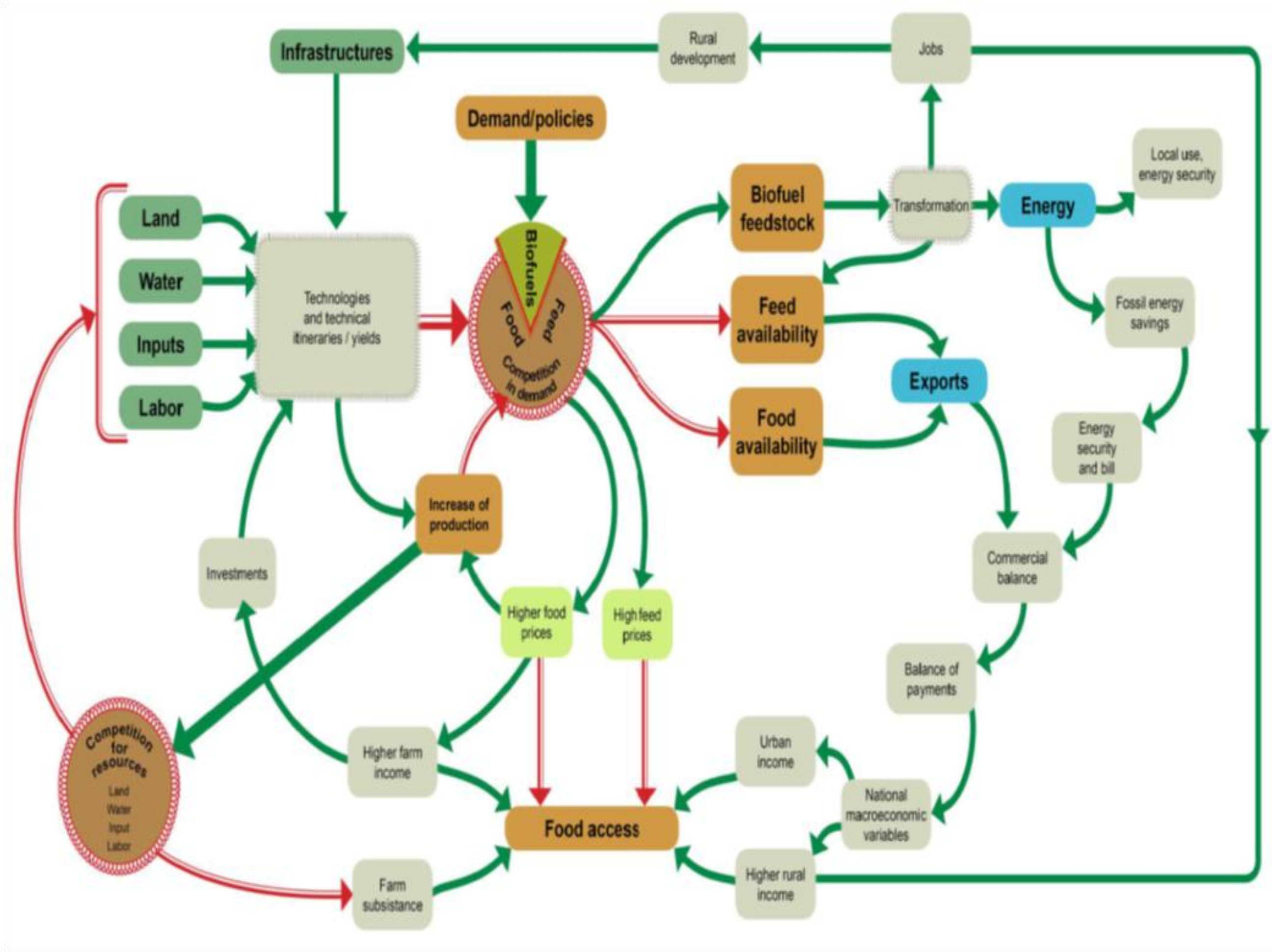
Factors	Subfactors
Low Stocks	Global market integration reduces the need for domestic stocks Demand growth exceeding production increase Lagging investments in agriculture • Low commodity prices in earlier years • Commodity prices below costs (dumping) Yield gap Food waste
Decreased Supply	Harvest failures (droughts and floods) Decrease in subsidized exports and food aid
Increasing Demand	Population and diet, obesity and luxury Importer policies (hoarding) Rapid expansion of biofuels (Future: biobased economy)
Increased Production Costs	Oil and Gas price Fertilizers
Market Dynamics	Speculation Trade restrictions (export bans, stockpiling) Currency exchange rates (weak dollar)

Source: Hamenlick, C., (2013), Biofuels and Food Security: Risks and opportunities, Ecofys, Chamber of Commerce 30161191, p. 9, Utrecht, The Netherlands

The aforementioned positive and negative impacts of biofuels and their interactions are schematically shown in Figure 3.

Green/plain arrow between A and B shows "positive" impacts (effect A acts to increase effect B). Red/hemstitched arrow shows "negative" impacts (effect A acts to lower/reduce effect B). It starts by biofuel demand/policies, which trigger increased competition for products, which then translates into effects (i) on the production system, including increased competition for resources (bottom/left of the figure), (ii) in households, including farm and non-farm (bottom of the figure), (iii) more broadly on the rural development and national economies (right side of the figure). No distinction is made here on the strength of each impact and feedback loops, nor between long-term or short-term impacts.

Figure 3. Representation of main impacts and feedbacks in the food, agriculture and energy systems following the introduction of a biofuel demand



Source: HLPE (2013), Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, p.23, Rome, Italy

1.2 Penetration & Prospects

1.2.1 View through renewables

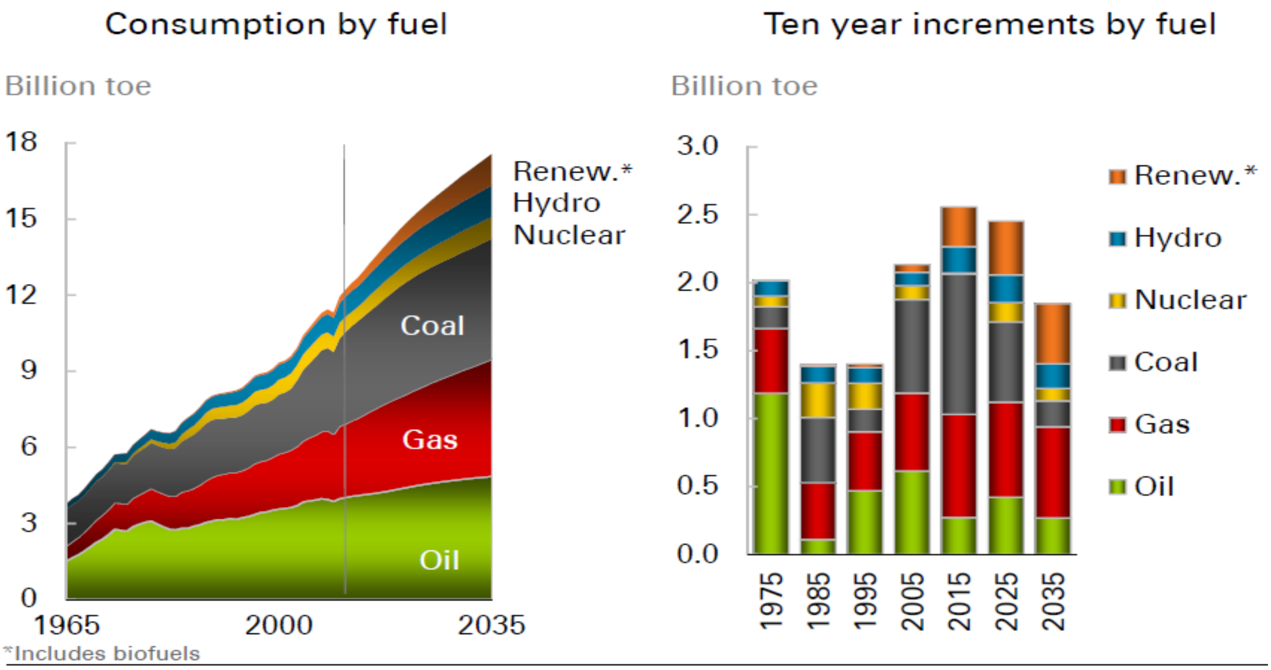
Renewable sources of energy have been increasing their market share in the global energy mix for more than 40 years. Renewable energy technologies became suddenly but briefly fashionable 4 decades ago in response to the oil embargoes of the 1970s, but the initially enthusiastic interest and support for their development was not sustained. In recent years however, dramatic improvements in the performance and affordability of solar cells, wind turbines and biofuels have paved the way for mass commercialization. What is more, high and wildly fluctuating prices for oil and natural gas have made renewable alternatives more appealing.

Renewables, including biofuels of course, ought not to be viewed outside the overall energy environment. According to the BP Energy Outlook 2035, the current phase of super high energy consumption growth, driven by the industrialization and electrification of non-OECD economies, notably China, will shortly be left behind. During 2002 to 2012, the largest ever growth of energy consumption in volume terms over any ten year period was recorded, and this is unlikely to be surpassed in our timeframe. In parallel, there is a clear long-run shift in energy growth from the OECD to the non-OECD. Virtually all (95%) of the projected growth is in the non-OECD, with energy consumption growing at 2.3% per annum from 2012 to 2035. OECD energy consumption, by contrast, grows at just 0.2% per annum over the whole period until 2030 and is actually falling from 2030 onwards.[17] The BP report is in accordance with Exxon Mobil 2015 report[18], which estimates that by 2040, China and India together are expected to account for half the growth in global energy demand because these two developing economies will be leading the world in terms of population size and the pace of growth in standards of living (China's population is expected to plateau around 2030, at 1.4 billion, enabling India to become the world's most populous country, with an anticipated 1.6 billion people by 2040).

In 2013, new renewable power capacity expanded at its fastest pace to date, while globally, renewable electricity generation was estimated on par with that from natural gas[19]. However, the renewables growth rate of former years is expected to level off through 2020, following the trend of global energy consumption in total, but will still be the highest among all fuels over the forecast period until 2035, estimated at 6.4% per annum.

[17] BP (2014), Energy outlook booklet 2035, p.9, BP, London, UK
[18] Exxon Mobil (2015), The outlook for energy: A view to 2040, p. 8, Exxon Mobil Corporation, Texas, USA
[19] IEA (2014), Renewable energy medium-term market report 2014, Executive Summary, Market analysis and forecasts to 2020, International National Agency, OECD/IEA, 2014, p.3, Paris, France

Figure 4. Projection of consumption by fuel

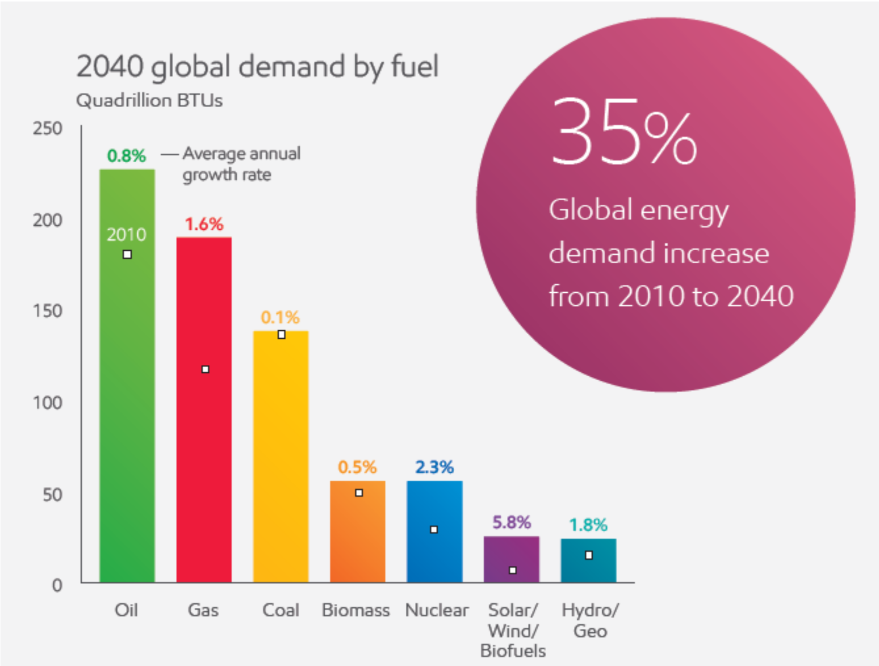


<u>**Source**</u>: BP (2014), Energy outlook booklet 2035, p.12, BP, London, UK

The above growth rate of the renewables (always including biofuels) enables them to increase their share from approximately 2% in 2014 to 7% by 2035, overtaking the share of nuclear energy by 2025 and matching at the end the one of hydro energy, according to the BP Outlook 2035 (2014).

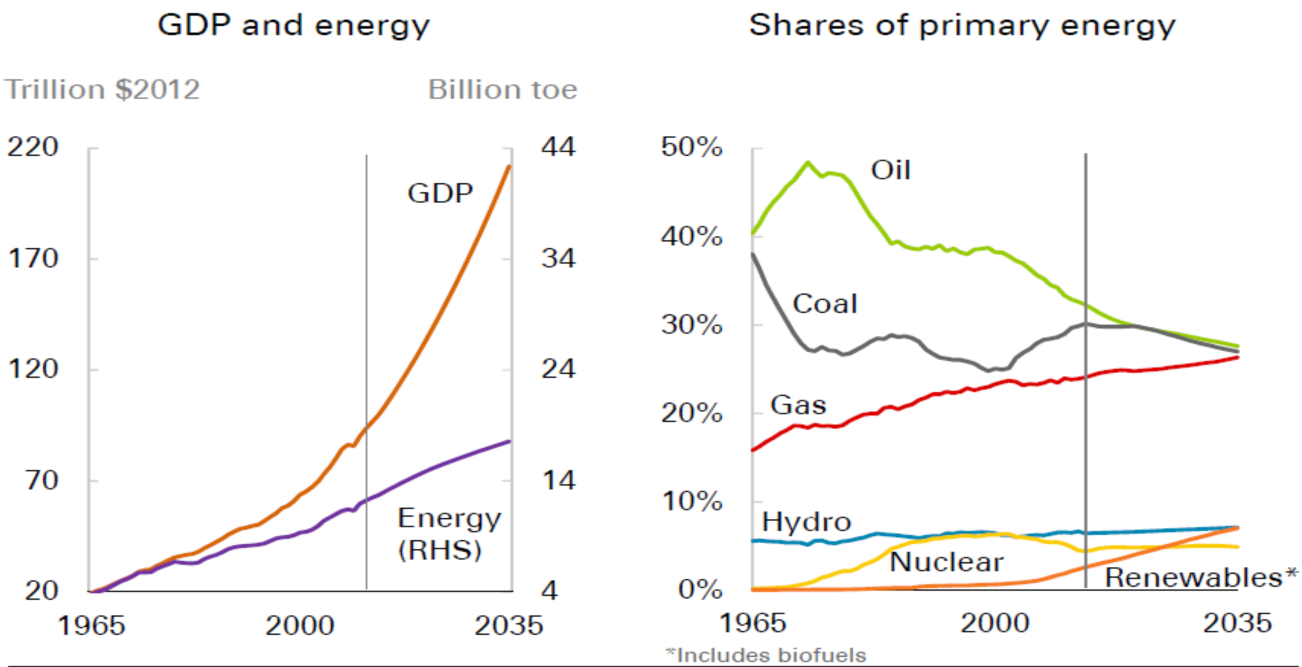
The above long term matching of biofuels share with hydro energy goes along with the Exxon Mobil Outlook 2040 (2015) as well. However, this is not the case regarding the overtaking of nuclear energy's share too, as Exxon Mobil estimates that nuclear energy will grow more than as fast as overall energy demand, driven by strong growth in the Asia Pacific (China and India included), assuming at the end double share in total energy demand compared to the renewables.

Figure 5. Global demand by fuel type



Source: Exxon Mobil (2015), The outlook for energy: A view to 2040, p. 57, Exxon Mobil Corporation, Texas, USA

Figure 6. GDP and Energy / Share of Primary Energy



Source: BP (2014), Energy outlook booklet 2035, p.16, BP, London, UK

It is worth noticing at the left section of the above figure the fact that the energy consumption growth rate is gradually since the early 1980s decoupling from the GDP growth rate. This historical declination has its roots in the increasing energy efficiency, driven by the technological evolution which plays a crucial role in decoupling economic growth and environmental pressure.[20]

1.2.2 In line with transportation

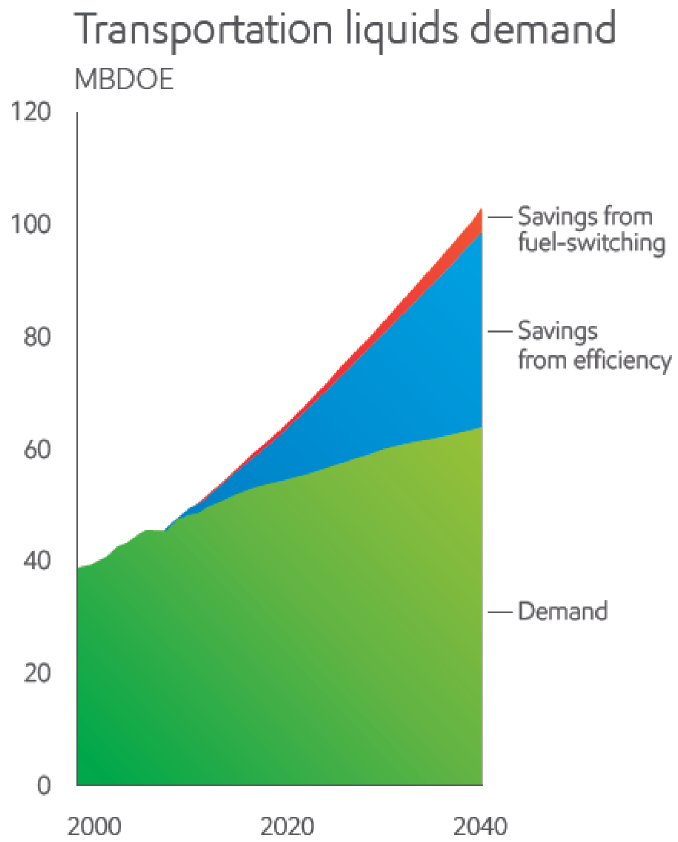
Since the transportation sector is by far the most important sector for the use of biofuels (due to their special properties of mixing with liquid fuels, as aforementioned in 1.1), its prospects are at least causal and at most crucial for the future of biofuels.

The rising prosperity around the world is expected to increase the fuel demand for transportation fuels. An expanding middle class, developing primarily in the non-OECD countries, will be buying vehicles for the first time and the growing commercial activity all over the globe will be in need of more liquid fuels too. According to the Exxon Mobil Outlook 2040 (2015), the global energy demand for transportation is expected to rise by 40 percent from 2010 to 2040 from approximately 45 MBDOE to 63 MBDOE (MBDOE stands for Million Barrels per Day of Oil Equivalent), while the global GDP is expected to rise by 140 percent during the same period.

On the other hand, the “rampaging” energy efficiency in vehicles mainly – BP Outlook 2035 (2014) estimates the fuel economy of vehicle fleet to improve by 2% per annum until 2035 – and the switching trend from traditional fuels such as Diesel (especially for the heavy-duty transportation sector) to compressed natural gas (CNG) and liquefied natural gas (LNG), will curb global liquids (petroleum products and biofuels) demand growth. According to Exxon Mobil Outlook 2040 (2015), the energy efficiency will save approximately about 35 MBDOE and the energy switch will account for about another 5 MBDOE. So, if the above reversing factors were to be set aside, the global demand for liquid fuels of the transportation sector would more or less double by 2040, as illustrated in the following figure.

[20] Mulder, P. and de Groot, H.L.F., (2005), Decoupling Economic Growth and Energy Use, p. 21, Tinbergen Institute Discussion Paper, Amsterdam, The Netherlands

Figure 7. Transportation liquid fuels demand



Source: Exxon Mobil (2015), The outlook for energy: A view to 2040, p. 23, Exxon Mobil Corporation, Texas, USA

1.2.3 Biofuels global perspective

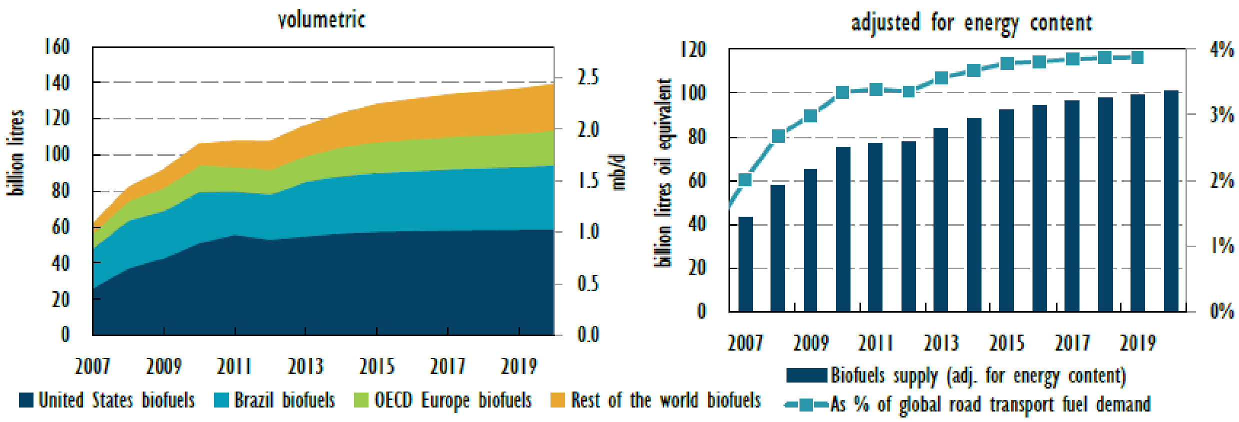
After a period of rapid growth, biofuel production and consumption in the United States, the European Union and Brazil appear to be shifting gears[21]. In the United States, the main center of ethanol productions and consumption globally, the design shortcomings of previous biofuel mandates have become manifest, leading to policy reviews that have introduced uncertainty in the market. In the BRICS (Brazil, Russia, India, China, South Africa) and particularly in Brazil, the second largest producer and consumer, the ethanol industry's economic situation is worsening, partly due to inflation-targeted gasoline price regulations that undermine ethanol economics. Brazil has been a pioneer in the production of biofuels, with a share of 20% in 1990. This share declined to a minimum of 12.5% in 2001 and stood at 22.8% in 2009[22]. In the European Union, ongoing controversy about the sustainability of biofuels has led to a proposed cap on conventional biofuel use that is leaving the industry in limbo until a final decision on the proposal is taken. At the same time, policy support is burgeoning in non-OECD countries, notably oil-importing economies

[21] IEA (2014), Renewable energy medium-term market report 2014, Executive Summary, Market analysis and forecasts to 2020, International National Agency, OECD/IEA, 2014, p.12, Paris, France
[22] Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.19, Paris, France

in Southeast Asia and Africa that subsidize fuel consumption, where rising domestic biofuel production promises a valuable option to lowering fuel import bills.

Compared to the total final consumption for road transport, the total amount of biofuels consumption is rather small (Figure 8). In 2014, all biofuels together had a share of 3.8% in global road transport consumption, which will be merely reaching 4% in the short term (by 2020).

Figure 8. World biofuels production, historical and projected in the short term.



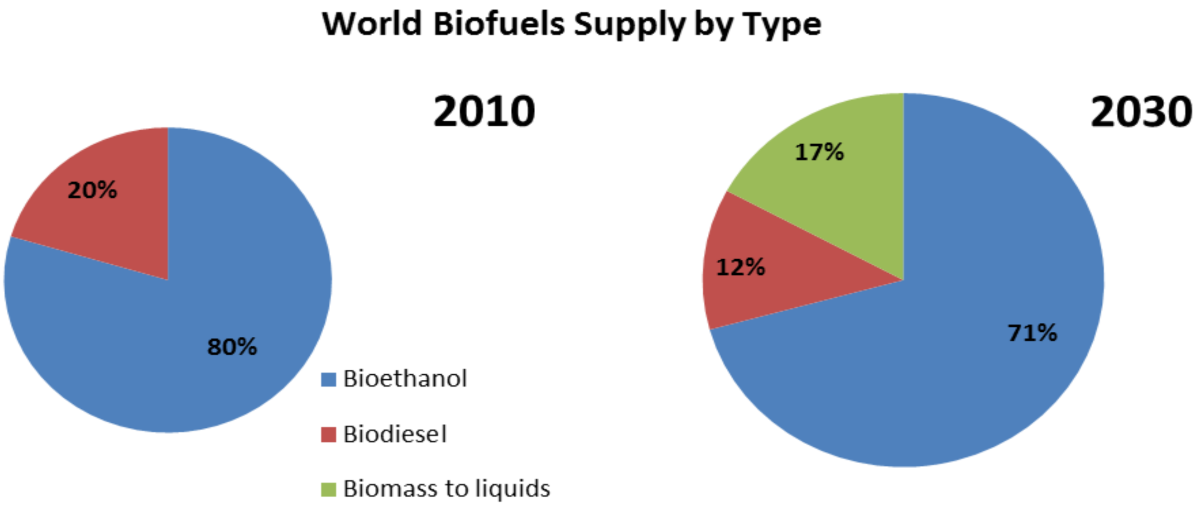
Source: Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.12, Paris, France

This 4% equivalent of global road transport, accounts for a biofuel production of approx. 140 billion liters in 2020. Meanwhile, the advanced biofuels industry faces headwinds, but capacity is expanding. Operating capacity reached almost 2 billion L in 2013, and could reach 4 billion L in 2020, if projects under development now in the pipeline continue as planned. Yet a number of companies have cancelled or postponed projects as they struggle to secure investments in light of an increasingly uncertain policy framework in the two key markets, the European Union and the United States. Developments in advanced biofuels also continue to remain limited to these two regions.[23]

Currently, the world biofuels supply is dominated by bioethanol, assuming a share of about 80% in 2010, which is estimated to decline to 71% by 2030. While the other dominant biofuels type, biodiesel, currently holding a 20% share is expected to lose approximately 40%, being substituted (bioethanol as well by approx. 10%) by biomass to liquids or BTL.[24]

[23] Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.12, Paris, France
[24] The term Biomass to Liquid BtL is applied to synthetic fuels made from biomass through a thermochemical route. The objective is to produce fuel components that are similar to those of current fossil-derived petrol (gasoline) and diesel fuels and hence can be used in existing fuel distribution systems and with standard engines. They are also known as synfuels.

Figure 9. World biofuels supply by type



Source: Alfstad, T.,(2008), World Biofuels Study, Scenario analysis of global biofuels markets, p.viii, Brookhaven National Laboratory, prepared for U.S. Department of Energy, Upton NY, USA

1.3 Policies and Regulatory Frameworks

Several developed and developing countries have established regulatory frameworks for biofuels, often including blending mandates of biofuels with fossil fuels. Countries have also provided different kinds of subsidies and incentives to support biofuel industries such as blending regulations, tax incentives, government purchasing policies and other measures.[25] This various policy mix globally has indisputably contributed to the development of infrastructure and technologies, successfully increasing the biofuels production on a worldwide scale. These developments have created a large international biofuel market, which amounted to 22.5 billion liters of biodiesel and 83.1 billion liters of bioethanol by 2012.[26]

The following analysis aims to provide an account of the most recent regulatory and policy developments in the countries of the largest, most developed or most emerging economies of the world, dividing them into regional groups according to common economic and geographical factors, following, except for the cases of the EU and the USA, the rationale of the IEA Global Renewable Energy Markets and Policies Program (GREMPP). The latter grouping consists of the five large emerging economies known as BRICS (Brazil, Russia, India, China, South Africa) and the ASEAN-

[25] World Energy Council (2010), Biofuels: Policies, Standards and Technologies, p.85-86, World Energy Council, London, United Kingdom, "Used by permission of the World Energy Council, London, www.worldenergy.org"

[26] Pacini et al, (2014), The State of Biofuels Market: Regulatory, trade and development perspectives, p. 77-78, prepared for the United Nations Conference on Trade and Development, United Nations Publication, New York, USA

6 (Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam), subset of member countries of Association of Southeast Asian Nations. The analysis will focus first on the country groupings of the GREMPP and continue with the United States of America, the European Union and in greater detail, with Greece.

1.3.1 The BRICS (Brazil, Russia, India, China, South Africa)

Among the BRICS countries, the production and use of biofuels has been and still is dominated by Brazil, with its ethanol program – the world's largest commercial program on biomass – being in place for more than 40 years. Brazil is currently the second biggest biofuels and ethanol producer in the world, accounting together with the United States for more than 80% of the world's ethanol.[27] The country's pioneer program targeted at producing bioethanol from sugarcane, developing the needed technology and ultimately reducing the country's dependence on imported petroleum products. Of course, the positive environmental effect of the use of biofuels instead of fossil fuels and the social benefits in terms of employment via the rural and industrial development, were taken under consideration too by the policy makers.[28] The widespread flex-fuel vehicle fleet (vehicles running on any combination of ethanol and gasoline) facilitates the use of bioethanol, allowing consumers to choose which fuel they purchase based on price and performance. Currently, the use of ethanol is being driven by a mandatory ethanol-blending regime, coupled with tax reductions for pure ethanol, with its mandatory blend level set at 25% (although it was reduced to 20% for a three-month period in early 2010 to reduce pressure on the sugar market). An obligation to blend 5% of biodiesel into diesel fuels came into effect in January 2010.[29]

Regarding Russia, no policies promoting the use of biofuels are currently in place. Nevertheless, the Russian government has declared in as early as 2008 that it would play an active role in developing the biofuel industry by building 30 new biofuel plants and providing tax breaks and subsidized interest rates to biofuel energy projects. Yet, these plans were delayed, and according to the Russian Ministry of Energy there are no government-backed biofuel projects in operation at this time. The majority of biofuel ventures are supported by regional governments or financed by foreign investors, while in most circumstances these projects are in the pilot phase and produce just enough biofuel to generate heat and/or electricity for their own facility, or for the production of organic fertilizer from agricultural waste. Moreover,

[27] Medeiros, M. & Froio, L., (2012), Actors, Interests and Strategies of Brazilian Foreign Policy on Biofuels, Brazilian Political Science Review, Sao Paolo, Brazil

[28] Pacini et al, (2014), The State of Biofuels Market: Regulatory, trade and development perspectives, p. 21-22, prepared for the United Nations Conference on Trade and Development, United Nations Publication, New York, USA

[29] Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.60-61, Paris, France

currently there is no industrial production of either bioethanol or biodiesel in Russia, except for several facilities that are operating in the regions and are supported by the regional administration or private companies.[30]

In India, for the first time in October 2007, the Union Council of Ministers of India made a series of announcements in relation to ethanol production, which included the establishment of a mandatory 5% blend of ethanol with petrol. India's states were given the option to increase this level to 10%. In 2009 the policy was updated through a National Policy on Biofuels, which sets an indicative target of a minimum 20% bioethanol and biodiesel share across the country by 2017. The policy also removed all central taxes on biodiesel and accorded declared goods' status to biofuels, which would ensure a uniform 4% sales tax on the product across states. India's national policy further focuses on indigenous production of biodiesel feedstock, not permitting the imports of free fatty acid (FFA)- based oil, such as palm, etc.[31] India' s government has also set up a mechanism, named Minimum Purchase Price (MPP) for the determination of biodiesel and bioethanol prices. According to this mechanism, the biodiesel MPP offered to the Oil Marketing Companies (OMCs) across the country, will be linked to the prevailing retail diesel price, whereas the bioethanol MPP will be based on the actual cost of production and import price of bioethanol. Following the latter methodologies, the final prices for both biodiesel and bioethanol will be determined by the Biofuel Steering Committee and decided by the National Biofuel Coordination Committee, chaired by the Prime Minister of India.[32]

In China, biofuels are included within the medium- and long-term plan for renewable energy, which calls for 50 million tons annually of biofuels. The plan emphasizes the need to focus on biofuels that do not threaten food security, so emphasis is placed on developing non-food biofuels and using land less amenable to crop cultivation to raise specific biofuel crops, such as Tung trees, cassava and sorghum, which could grow on marginal land. However, these crops present relatively low yields and small-scale production that are unable to support large-scale biofuel production. Plants that manufacture both ethanol and biodiesel have received support from the government, and R&D on production from indigenous sources continues. China also has R&D efforts under way to develop advanced biofuels from lignocellulosic ethanol, with the first pilot plants now operating. Most fuel ethanol is produced by state-run enterprises and blended and marketed through the state-run petroleum companies.[33] Regarding blending mandates, biodiesel is under no national or provincial mandate due to the lack of large scale production

---

[30] Muran, M., (2014), Russian Federation, Biofuels Annual: Biofuels Sector Update, USDA Foreign Agricultural Service, p.2, Moscow, Russia

[31] Muller, S., Marmion A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.62, Paris, France

[32] Government of India (2008), National Policy on Biofuels, Ministry of New & Renewable Energy on India, p.10, New Delhi, India

[33] Muller, S., Marmion A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.62, Paris, France

infrastructure. In an effort to stimulate its production, the Chinese government removed a five percent consumption tax in 2010, resulting in a production/consumption increase of approx. 50% within 2 years.[34] A different approach has been adopted for bioethanol, with national blending mandates being in place since the early 2000s. The current blending with gasoline is set at 10%, however in practice, the rate ranges between 8 and 12 percent. Further to the bioethanol blending mandate, subsidies are in force, although they have diminished from $0.19 per liter in 2009 to $0.06 per liter in 2012.[35] The 12th Five-Year Plan (2011 – 2015) targets the generation of seven million tons of biomass liquid fuels production capacity by 2015 and also includes a new consumer tax exemption for the consumption of pure biodiesel from waste animal and plant oil.

In South Africa, in 2006, a draft Strategy approved by the Cabinet for public comments, was initially formulated, proposing a target of 4.5% penetration of biofuels in the national liquid fuels supply. The draft Strategy was soon succeeded by the Biofuels Industrial Strategy which was approved in December 2007 and revised the national target for 2%, equivalent to some 400 million liters per year, based on using sugar cane, sugar beet, sunflower, soybeans and canola. The consumption of ethanol is encouraged by a 100% fuel levy exemption for bioethanol and 50% for biodiesel. However, the target has been pushed back and will not be enforced until the industry is able to secure the necessary supply.[36]

1.3.2 ASEAN-6 (Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam)

Although all ASEAN-6 countries produce biofuels, biofuels for road transport are nearly absent in them, with Philippines and Thailand scoring a penetration of merely 3 percent in total road transport fuels, in 2009.[37] Most of their production is exported with the exception of Philippines which imports biofuels as well. Blending mandates have been implemented in all ASEAN-6 countries except Singapore.

In Philippines, from 2006 until nowadays, the biodiesel blending limit has been set at 2 percent in all locally distributed fuels. The blending mandate has been announced to increase at 5 percent in 2016.[38] Being the world's largest coconut oil producer, the current threshold has been conquered without problems and there is

---

[34] Scott, R., Junyang, J. & Riedel, M., (2013), People's Republic of China Biofuels Annual 2013, USDA Foreign Agricultural Service, Beijing, China

[35] Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, p.38-39, Geneva, Switzerland

[36] Government of South Africa, (2007), Biofuels Industrial Strategy of the Republic of South Africa, Department of Minerals and Energy, p.3-4, Pretoria, South Africa

[37] Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.91, Paris, France

[38] Corpuz, P., (2015), Philippines Biofuels Annual: Philippines Biofuels Situation and Outlook, USDA Foreign Agricultural Service, p. 2, Manila, Philipinnes

no concern about the future limit either. In the case of bioethanol, where the blending mandate has been set from 2006 at 10 percent, the government has been opposed with compliance issues due to the inadequacy of the local bioethanol production, resulting in import dependency especially from Thailand.[39]

The biofuels policy in Thailand is governed by the "10 – year Alternative Energy Development Plan (2012 – 2021), which aims at increasing the share of renewable and alternative energy from 9.4 percent of total energy consumption in 2012 to 25 percent by 2021. 44 percent of biofuels used in transport should be replaced with biofuels. Thailand is a large producer of bioethanol, with total production capacity of 4.2 million liters per day, dominated by molasses-based ethanol (about 75 percent of total production). Although no blending mandate for bioethanol is in place, the leader gasoline fuel is E10 and the military government strongly promotes the use of E20 and E85 gasoline through price incentives and tax exemptions for the manufacturing of E20 and Flex-Fuel compatible vehicles.[40] Biodiesel production and consumption remains marginal compared with bioethanol, approx. 1.250 million liters in 2015, using mainly crude palm oil as feedstock. The blending mandate was recently increased from 5 to 7 percent (in 2014).

Indonesia being the world's largest palm oil producer (it overtook Malaysia in 2007) is mainly focused on biodiesel for local consumption as well as for exports, while its bioethanol consumption and production is merely absent. Established in 2006, the "National Energy Policy" formalized the development of biofuels in Indonesia, aiming initially to achieve a five percent penetration of biofuels by 2025.[41]

Since then, several biodiesel blending mandates have been set: up to 2015 at 10%, revised in December 2015 at 15%. These mandates have been accompanied historically by subsidizing mechanisms, the latest one named the "New Plantation Fund", which will be imposing a levy on palm oil exports. These funds will be used in order to bridge the gap between the market index price of conventional diesel and biodiesel. Despite, the country's aggressive blending mandates and subsidies' programs, the national targets remain underachieved, with the domestic consumption of biodiesel in 2014 accounting only for 40% of the mandatory target.[42]

Regarding Singapore, neither a policy on biofuels nor a national target on renewable energy in transport has been announced so far.[43]

---

[39] Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, p.41-42, Geneva, Switzerland

[40] Preechajarn et al, (2013), Thailand Biofuels Annual, USDA Foreign Agricultural Service, p.3, Bangkok, Thailand

[41] Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, p.45-46, Geneva, Switzerland

[42] Wright, T. & Rahmanulloh, A., (2015), Indonesia Biofuels Annual, USDA Foreign Agricultural Service, p.2-3, Jakarta, Indonesia

[43] IRENA (2015), Renewable Energy Target Setting, p.66

Vietnam's policy on biofuels is governed by two programs, established in 2007, "The National energy development strategy up to 2020, with 2050 vision" (Decision 1855/QD-TTg, December 27, 2007) and "The National program for development bio-fuels up to 2015, with 2025 vision" (Decision No 177/2007/QD-TTg on November 20, 2007). Their ultimate target is to satisfy 5% of the whole country's gasoline and oil demand by 2025. Bioethanol is dominating Vietnam's domestic production and consumption. Currently the E5 (gasoline blended with bioethanol at 5%) is mandatory throughout the country and the target is to turn to E10 from 1st December 2017. Further to the blending mandates, E5 and E10 are supported with a tax exemption (lower environment protection fee compared to unblended gasoline) and for the protection of domestic ethanol plants, an import tax of 20%, has been imposed on importing ethanol from 2014 and on.[44]

1.3.3 USA

The U.S. has been trying since 25 years ago, beginning with the Energy Policy Act of 1992, to build a sustainable biofuels industry in two ways: by imposing quantity-based constraints on biofuels productions and by offering biofuel producers a package of financial, primarily tax-related incentives (although some of the incentives have now expired). The Congress passed several pieces of energy legislation to introduce Renewable Fuels Standards (RFS). The RFS requires producing and blending of several different classes of biofuels, eventually requiring 36 billion gallons per year of biofuels be blended with petroleum fuels in 2022. Federal policies consist of productions mandates, greenhouse gas requirements for biofuels and tax credits for ethanol and biodiesel. In addition to the federal policies, several states have developed their own policy mix so as to promote and support the biofuels production and/or usage within their own territory.[45]

The following table provides a comprehensive listing of the main US legislations and regulations as identified by the UNCTAD in 2014.

[44] Van Dinh Son Tho, (2014), Current statute of biofuel production in Vietnam, School of Chemical Engineering, Hanoi University of Science and Technology, Hanoi, Vietnam
[45] Adusumilli, N. & Leidner, A., (2014), The U.S. Biofuel Policy: Review of Economic and Environmental Implications. American Journal of Environmental Protection, vol. 2, p.64-70, Texas, USA

Table 4. Key regulation and legislation in the USA.

Farm Security and Rural Investment Act	The Farm Bill establishes new programs and grants for procurement of bio-based products to support development of biorefineries, to educate the public about benefits of biodiesel fuel use, and to assist eligible farmers, ranchers and rural small businesses in purchasing renewable energy systems. It allows payments to eligible producers to encourage increased purchases of energy feedstocks for the purpose of expanding production of bioenergy and supporting new production capacity.
Energy Policy Act	The 2005 Energy Policy Act repealed the Clean Air Act requirement that reformulated gasoline contain at least 2 percent oxygen by weight (MTBE and ethanol being the most commonly used oxygenates in the past). In place of this requirement, the bill establishes a Renewable Fuels Standards (RFS).
Renewable Fuel Standards and Related Legislation	The first RFS was enacted as part of the Energy Policy Act of 2005 and required about 28 bnl of renewable fuel to be blended into gasoline by 2012. The second and current Renewable Fuel Standard (RFS2) was enacted with the Energy Independence and Security Act of 2007 (EISA2007). EISA2007 explicitly prohibits bioethanol derived from corn starch from being considered as an advanced biofuel. Within the advanced class there are also specific volume requirements for three subcategories of advanced biofuels: unspecified, cellulosic biofuels, and biomass-based diesel. The EISA2007 statute created two principal categories renewable fuels pr pa go (subsequently referred to as includes virtually all renewable fuels produced by facilities that existed or were under construction in 2008 and any new sources of renewable fuel meeting a 20-percent reduction in GHG emissions relative to the fuels displaced (gasoline or diesel) from 2005 baseline. Advanced biofuels, which include fuels such as sugarcane ethanol, require a 50 percent GHG emissions reduction. Biomass-based diesel requires the same 50 percent. Finally, cellulosic biofuel with 60 percent GHG emissions reduction.
California Low Carbon Fuel Standard (LCFS)	LCFS implementation began in January 2011 but was halted by an injunction in December 2011 as two separate lawsuits worked their way through the state and federal courts. The injunction was lifted in April 2012 but litigation continues. Under the LCFS, every fuel has its own demonstrated level of lifecycle GHG emissions. The level of GHG emissions is expressed as a value of CO_2 equivalent per unit of energy, in order to consistently account for GHG other than CO_2. The standard requires substitutes for fossil fuels that demonstrate lower lifecycle GHG emissions than the fuels they replace. Each gasoline or diesel substitute is assigned one or more pathways with unique levels of GHG emissions based on raw material production and biofuel production.
Ethanol Blending	In March 2009, Growth Energy and a number of ethanol producers petitioned the US Environmental Protection Agency (US EPA) to approve the use of up to 15 percent bioethanol by volume in finished gasoline (E15). In October 2010, US EPA approved the use of E15 in vehicles of model year 2007 and later after conducting vehicle tests in conjunction with the Department of Energy. In January 2011, US EPA approved the use of E15 in light-duty vehicles beginning with model year 2001. The ethanol industry was also trying to persuade Congress to pass legislation to allow the same 1-pound Reid Vapor Pressure (RVP) waiver for E15 that is currently allowed for summer-grade conventional gasoline blended with 10 percent ethanol. This waiver would make the marketing of E15 less costly in the summer months, when gasoline volatility is required to be lower for air quality reasons. Approximately two-thirds of US gasoline volume is subject to the existing 1-pound waiver. As of January 2011, the vehicles covered by the two E15 waivers were estimated to be 60 percent of vehicles on US roads. Automakers, however, continue to oppose the use of E15 in any vehicle that is not capable of using high ethanol blends up to E85. E10 will continue to be the limit for light vehicles built prior to model year 2001, all gasoline-powered heavy-duty vehicles, and all non-road equipment. At the end of 2011, industry and regulators were working on health effects testing of E15 and pump certification, which are required to be addressed before E15 can be marketed. In 2012 US EPA began accepting submissions from retailers for approval to offer E15 blends. Numerous companies applied and were approved, with the first liter of E15 gasoline being sold in July 2012. As of August 2012, E15 is still limited by the same liability, warranty, and distribution concerns that were present in 2011 despite the first official volumes of the fuel making their way into the market. While small volumes of the fuel are likely to continue being sold in select locations around the country, they are likely to remain marginal relative to the total ethanol supply until these issues are resolved.
Ethanol Tariffs and Tax Credits	Gasoline blended with bioethanol received a partial exemption from the motor fuels excise tax. This exemption made bioethanol-blended fuel price-competitive with gasoline. In 2005, the excise tax exemption was replaced by a tax credit (Volumetric Ethanol Excise Tax Credit - VEETC). VEETC was the most significant among the numerous US federal and state level tax incentives put in place to boost bioethanol use. The tax credit of \$0.12 per liter of bioethanol blended with gasoline expired on December 31, 2011. High petroleum prices, record ethanol production, the saturation of the gasoline pool with ethanol, a robust federal RFS2 mandate, and a need to reduce federal tax expenditures all contributed to the expiration of the credit. Until the end of 2011, imports of bioethanol were subject to a tariff of \$0.14 per liter. The tariff was intended to offset the bioethanol blending tax credit, so that only domestic bioethanol producers would benefit from the credit. The idea was to prevent large-scale direct imports from Brazil. There were, however, two ways to import bioethanol without tariff liability. One way was to ship ethanol from Brazil to the Caribbean for further processing. The ethanol could then be imported tariff-free under the Caribbean Basin Initiative. Another way was to offset fuel ethanol imports with exports of US produced bioethanol and claim a duty drawback. This provision came into play in 2011, when corn ethanol was essentially swapped for the sugarcane ethanol needed to meet

	the RFS2 and the LCFS.
Biodiesel Blending	Biodiesel use is also required by various state and local mandates. Minnesota, the first state to require that all gasoline be blended with bioethanol, also led the way with a 2 percent biodiesel (B2) requirement in all diesel fuel. More recent state legislative activity has focused on heating oil. The biodiesel content requirements for states and localities mandating biodiesel (e.g. Minnesota, Oregon, Pennsylvania, Washington, New York City, and Vermont) range from 2 up to 20 percent. In addition, New Mexico and Massachusetts have suspended B2 legislation and Louisiana has a B2 mandate passed in 2006 that has not been implemented.
Biodiesel Tax Credit	The credit for biodiesel blending into diesel fuel or heating oil is $0.26 per liter of biodiesel blended. This tax credit was allowed to expire at the end of 2009, contributing to a decline in biodiesel production in 2010. At the end of 2010, the biodiesel credit was reintroduced for 2011 and made retroactive for all of 2010. The RSF2 also played a role in the biodiesel industry's comeback in 2010 and 2011, because biodiesel is necessary to meet the biomass-based diesel requirement.
Cellulosic Biofuels Producer Tax Incentives	Producers of cellulosic biofuels are eligible for a production tax credit of $0.27 for each liter. An incentive depreciation allowance is also available for cellulosic biofuel plant property. Both of these incentives expire at the end of 2012

Source: Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, p.10-12, Geneva, Switzerland

1.3.4 European Union

By 2000, several member countries of the EU had introduced biofuels targets and blending mandates so as to promote the growth of biofuels, driven by environmental and energy security concerns, as well as the strategy aiming to advance economic development and employment within the rural sector.[46] The first major and coordinated political act was the implementation of the 2003 European Directive (Directive 2003/30/EC), which placed a proportion target of biofuels and other renewable fuels by 2005 at 2% and by 2010 at 5.75% of total energy for transport. However, the share of biofuels in transport fuels in 2005 was 0.9% and in 2010 3.7% according to the EU Commission Energy Statistics.[47]

The 2003 Directive was followed by a more massive and ambitious political act, the 2009 Renewable Energy Directive (RED), part of the CCP (the EU Energy and Climate Change Package), whereas inter alia, "Each Member State shall ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10% of the final consumption of energy in transport in that Member State".[48] It is worth noting the following aspects specified by the RED, as pointed out by the CE Delft and TNO report "Bringing biofuels on the market"[49], which was produced for the European Commission:

[46] Muller, S., Marmion, A., Beerepoot M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, p.43, Paris, France
[47] EU Commission (2015), EU-28 Energy datasheets, Energy Statistics, EU Commission, DG ENER, Unit A4, Eurostat, p.6
[48] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, Article 3, Paragraph 4.
[49] Kampman B. et al, (2013), Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits, CE Delft, p.19-20, The Hague, Netherlands

a) For the calculation of the denominator, i.e. the amount of fuel of which 10% should be renewable in 2020, the total amount of petrol, diesel, biofuels consumed in road and rail transport, and electricity shall be taken into account.

b) For the calculation of the numerator, i.e. the amount of renewable energy in transport, all types of energy from renewable sources consumed in all forms of transport shall be taken into account.

c) The contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels.

d) A number of sustainability criteria for biofuels are defined that need to be met if the biofuel is counted towards the 10% target. These criteria define the methodology to calculate the GHG emissions of biofuels, set minimum GHG reduction levels, exclude biofuels from biomass that is cultivated in areas with high biodiversity or high carbon content of the soil, etc.

In order to ensure the fulfillment of the targets, the Directive required the 28 member states submit their own National Renewable Energy Action Plans (NREAPs) by June 30, 2010, which will be providing very detailed roadmaps of how each member state expects to reach its legally binding 2020 target. The information in the total of the submitted NREAPs predicts that the overall share of renewables in 2020 will be 20.7 percent, slightly above the 2020 target.[50]

Even before the adoption of the RED, a debate around the impact of indirect land use change (ILUC) on GHG emissions has been carrying on: the ILUC relates to the unintended consequence of releasing more carbon emissions due to land-use changes around the world induced by the expansion of croplands for ethanol or biodiesel production in response to the increased global demand for biofuels. The Directive intended to put an end on it by developing "a concrete methodology to minimize greenhouse gas emissions caused by indirect land-use changes. To this end, the Commission should analyze, on the basis of best available scientific evidence, in particular, the inclusion of a factor for indirect land-use changes in the calculation of greenhouse gas emissions and the need to incentivize sustainable biofuels which minimize the impacts of land-use change and improve biofuel sustainability with respect to indirect land-use change."[51] Consequently, after the official report about the above impact was submitted and about five years of discussions and negotiations, on April 28 2015, the European Parliament approved the compromise agreement on the reform of the RED, which included a 7 percent calculation cap on crop based biofuels, also known as conventional biofuels, in the EU's renewable

[50] Flach, R. et al, (2013), EU Biofuels Annual 2013, USDA Foreign Agricultural Service, p.10, The Hague, Netherlands

[51] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, Article 3, Paragraph 4

energy target for its transport sector for 2020, and included indirect land use change (ILUC) factors only for reporting purposes. The Council now has to confirm the Parliament's vote, which is expected by the end of 2015. If it is approved, the Member States will have to enact the new legislation by 2017.[52]

The 2009 Renewable Energy Directive was complemented and reinforced by another legislative action in 2009, the 2009/30/EC Fuel Quality Directive (FQD), which revised the Fuel Quality Directive of 1998 (1998/70/EC). The Directive amended a number of elements of the petrol and diesel specifications and introduced the Article 7a, a requirement on fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport (Low Carbon Fuel Standard). Furthermore, the FQD, in Article 7b, established certain sustainability criteria that must be met by biofuels if they are to count towards the greenhouse gas intensity reduction obligation.[53]

The key aspects of the above Directives (RED and FQD), directly related to biofuels are the following:

1. Double counting: "the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels".[54] This measure is clearly a strong incentive in favor of the second generation or "advanced" biofuels.
2. Sustainability criteria: In order to qualify for both the RED and FQD targets, biofuels consumed in the EU must comply with strict sustainability criteria provided in Article 17 of the RED. Otherwise, they cannot be eligible for financial support or to count towards the EU renewable energy target. Rigorous requirements are set in the RED on the minimum level of GHG savings, appropriate land use, as well as monitoring requirements for any potentially adverse effects.[55]
3. GHG (greenhouse gas) emissions: The GHG emissions for biofuels are calculated with the use of default values, which have been explicitly outlined in the FDQ and listed in the Annex V of RED. Actually in the Directives, there is a list of default GHG values for different parts of the biofuel production chain (cultivation, process, transports). The economic operators can choose to use the default values (if the biofuel chain corresponds to those listed in the Directives), their own calculated actual values, or a combination of default and actual values. Calculation of actual values is made according to life cycle assessment methodology and the calculation rules are described in the annexes of the Directives. In the case of land use change, the carbon emissions

[52] Flach, R. et al, (2015), EU Biofuels Annual 2015, USDA Foreign Agricultural Service, p.10, The Hague, Netherlands, p.1

[53] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009

[54] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, Article 21, Paragraph 2

[55] Flach, R. et al, (2015), EU Biofuels Annual 2015, USDA Foreign Agricultural Service, p.10, The Hague, Netherlands

associated must be included as well. If any by-products arise in the process, the emissions are allocated (divided) over the different products, based on their energy content. There are also a number of emissions that can be subtracted. For example, if improved agricultural management captures more carbon in the soil or if excess electricity is produced in the biofuel plant, while there is also a GHG bonus if severely degraded land is used for the cultivation of energy plants.[56]

4. Certification systems: In order to ensure that the biofuels used meet the sustainability and GHG savings requirements of the RED, they need to be certified by one of the voluntary certification systems. Some Member States have developed their own national voluntary systems, while others rely on voluntary schemes adopted by the European Commission. As of April 2015, the following 19 voluntary schemes that can certify biofuels for all Member States have been approved by the European Commission:

   1) ISCC (International Sustainability and Carbon Certification)
   2) Bonsucro EU
   3) RTRS EU RED (Round Table on Responsible Soy EU RED)
   4) RSB EU RED (Round Table of Sustainable Biofuels EU RED)
   5) 2BSvs (Biomass & biofuels voluntary scheme)
   6) RBSA (Abengoa RED Bioenergy Sustainability Assurance)
   7) Greenergy (Brazilian bioethanol verification program)
   8) Ensus (Voluntary scheme under RED for Ensus bioethanol production)
   9) Red Tractor (Farm Assurance Combinable Crops & Sugar Beet Scheme)
   10) SQC (Scottish Quality Farm Assured Combinable Crops scheme)
   11) Red Cert
   12) NTA 8080 (The Netherlands)
   13) RSPO RED (Roundtable on Sustainable Palm Oil RED)
   14) Biograce (GHG calculation tool)
   15) HVO Renewable Diesel Scheme
   16) Gafta Trade Assurance Scheme
   17) KZR INIG (Oil and Gas Institute of Poland)
   18) Trade Assurance Scheme for Combinable Crops
   19) Universal Feed Assurance Scheme

5. Biomass Sustainability: Despite the fact that the RED demanded from the European Commission to assess whether or not sustainability criteria for solid and gaseous biomass were required, in May 2014 the EC reported that there would be no EU-wide sustainability criteria for biomass before 2020. This decision was based on the assumption that the current national, European and

[56] The Swedish Knowledge Centre for Renewable Transportation Fuels (2015), EU sustainability criteria for biofuels, Göteborg, Sweden

international legislation is sufficient to ensure that the proper and sustainable practices are being used. Nevertheless, it is expected that the EC will develop a biomass policy aimed at maximizing the overall climate and environment benefits of biomass and contributing to significant GHG emission savings for 2020 until 2030.[57]

With regards to the EU's trade policy for biofuels, several anti-dumping and import duties have been applied since 2006, which aimed at the protection of the domestic market and motivated or demotivated imports from certain markets on case by case. During 2006 – 2012, the EU import tariff on undenaturated bioethanol was 88% percent higher than the tariff on denaturated bioethanol, while at the same time most of the Member States, with the exemption of the United Kingdom, the Netherlands, Finland, Denmark, the Czech Republic and Slovakia, only permitted blending with the undenaturated form of it.[58]

Furthermore and with reference to the imports from the United States, where as mentioned before (in §1.2.3), the bioethanol production is huge and robust, in 2013, the European Commission adopted Council Regulation (157/2013) which imposed a definitive anti-dumping duty on import of bioethanol originating in the United States. The rate of the anti-dumping duty is set at €62.3 per metric ton (MT), and is applicable in proportion by weight of the total content of pure ethyl alcohol produced from agricultural products. Ethanol for other uses than for fuel is exempted from this anti-dumping duty.[59] In the case of biodiesel, EU has been following a similar policy of protectionism for its Members' domestic interests. Through the adoption of Regulations 193 and 194 in 2009, anti-dumping and countervailing duty measures on imports of biodiesel from the United States containing 20 percent or more of biofuels were enforced. The latter measures were meant to expire by July 2014, but after the request of the European Biodiesel Board which demanded their extension claiming that subsidized imports would be offered at dumping prices, the European Commission undertook an investigation so as to decide respectively. In September 2015, EU published the Regulations 1518 and 1519 extending the so-called "B99" measures (anti-dumping and anti-subsidy duties on US biodiesel imports) for another five years.[60] Such measures have also been applied for biodiesel imports originating in Argentina and Indonesia (Regulation 490/2013). Initially the measures were designed to have duration for a certain time, yet they were made permanent later in 2013 with the Regulation 1194.

[57] Flach, R. et al, (2015), EU Biofuels Annual 2015, USDA Foreign Agricultural Service, p.10, The Hague, Netherlands

[58] Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, p.18, Geneva, Switzerland

[59] Flach, R. et al, (2015), EU Biofuels Annual 2015, USDA Foreign Agricultural Service, p.13, The Hague, Netherlands

[60] European Biodiesel Board (2015), Press Release: The EU biodiesel industry welcomes the regulations extending the "B99" measures against US biodiesel imports, EBB, Brussels, Belgium

1.3.5 Greece

Being a member state of the European Communities (the 3 predecessor international organizations of the European Union) since 1981, Greece has been closely adopting the EU legislation and regulations with limited differentiations where and if it is allowed and requested.

The European Directive (Directive 2003/30/EC) was adopted by amending and supplementing Law 3054/2002 (Organization of the oil market and miscellaneous provisions) with Law 3423/2005 (Introduction of biofuels and other renewable fuels in the Greek market). In 2012, the latest European Directives concerning biofuels, 2009/28/EC and 2009/30/EC, were adopted in Law 4062/2012 in section C and chapters A (Promotion of energy use from renewable sources – integration of European Directive 2009/28/EC) and B (Sustainability criteria of biofuels and bioliquids - integration of European Directive 2009/30/EC), as published on 30 March 3012.

In the scope of Directive 2009/28/EC, Greece elaborated and submitted its National Renewable Energy Action Plan in June 2010. According to the NREAP, the targeted 20% share of renewable energy in the gross final energy consumption in 2020 will be achieved through the combination of measures for energy efficiency as well as for the enhanced penetration of RES technologies in electricity production, heat supply, and transport. With regards to the pillar of Renewable Energy Sources in Transport, the NREAP states:

"*The penetration of biofuels to meet the 20-20-20 target in the transport sector will be achieved through a combination of regulatory actions targeted to promote both the use of more energy-efficient vehicles and the consumption of biofuels in substitution of fossil transport fuels. Emphasis will be put on the domestic production of the required amounts of biodiesel, on the exploitation of the local biomass potential with the cultivation of energy crops for biofuels and on the development of the necessary supply chains in order to assure a significant contribution of the domestic agricultural production.*"[61]

Through the article 1d Law 3851/2010, the national target for the contribution of renewable energy sources in the final consumption of energy in the transport sector, has been set to reach at least 10% by year 2020.

[61] National Renewable Energy Plan, (2010), Ministry of environment, energy & climate change, Hellenic Republic, p.9, Athens, Greece

Biodiesel

Blending of biodiesel

The actual blending of biodiesel with diesel began at the end of 2005 at a rate of 2.5%. Within five years it was progressively increased at 5.75 and from 2013 until now it is regulated at 7%[62]. However, Fuel Retailers are allowed to offer automotive diesel with even higher than 7% biodiesel blend, provided that there is a respectively special labelling at the selling points (although this option has not been utilized yet).
Initially and until the end of December 2007, in order to promote the consumption of biodiesel, a tax exemption from automotive diesel's excise duty for the amount of biodiesel in the final blend was in force. After the tax exemption termination, the quota of biodiesel blended with diesel bears the same excise duty with diesel (the excise duty was 293 €/1000 Liters in 2008 and is now set at 330 €/1000 Liters).

Biodiesel Allocation Program

Biodiesel Call

According to Law 3054/2002 and its amendments, it is mandatory for the producers and distributors of petrol and diesel to blend their fuels with a certain amount, "quota" of biofuels which is specified in the distribution scheme, reviewed every year (art. 15A par. 3 Law No. 3054/2002 which was incorporated in Law 3054/2002 amended by the art. 3 of Law 3423/2005, the art. 55 of Law 3653/2008 and art. 22 of Law 3769/2002). Every year, before the 15th of April, a Ministerial Decision by the Ministry of Environment and Energy is issued that determines the total quantity of biodiesel to be allocated to beneficiaries for the coming year (from July 1st of current year to June 31st of coming year) and calls any candidate beneficiaries to submit their will to participate in the allocation program. For the determination of the total allocation quantity of biodiesel, the following two parameters are mainly taken into consideration: 1) the maximum blending rate of biodiesel with diesel as defined by the Supreme Chemical Council (SCC) and 2) the 85% of the estimation of automotive diesel consumption for the year to come[63], as submitted by the two local Refiners (Hellenic Petroleum S.A. and Motor Oil Corinth Refineries S.A.).

[62] The no. 30/005/795 / 12.20.2012 document of the Directorate of Petrochemicals of the General Directorate of the State General Laboratory states that with respect to the maximum deviation on the fatty acid methyl ester contained in a mixture of automotive diesel with pure biodiesel, the laboratory differential method for mixing is 7% + - 0,3 (EN 14078), so that that the mixture is considered within specification.

[63] Determination of criteria and methodology of pure biodiesel allocation and regulation of any related issue, according to the provisions of art. 15A of Law 3054/2002, as is in force (2013), Δ1/Α/οικ.2497, p.3, Ministry of Environment and Energy, Athens, Greece

Table 5. Yearly Biodiesel allocation quantity and blending rate with automotive diesel

YEAR	BIODIESEL QUANTITY (L)	BLENDING RATE (%)
2005	2.500	2,00
2006	91.000	3,00
2007	114.000	4,00
2008	123.000	4,50
2009	154.750	5,00
2010	164.000	5,75
2011	132.000	6,50
2012	132.000	6,50
2013	92.000	7,00
2014	133.000	7,00
2015	140.000	7,00
2016	132.000	7,00

Source: Data retrieved from Ministry of Environment and Energy (www.ypeka.gr) and Foundation for economic & industrial research (2010), The sector of renewable fuels in Greece: issues and prospects, p.16, Athens, Greece

Following the determination of the total allocation quantity, the process of the beneficiaries' qualification and allocation per beneficiary begins, led by a joint ministerial committee assembled by three members one from each ministry (Ministry of Finance, Ministry of Rural Development and Food, Ministry of Development).

Beneficiaries' Qualification

Beneficiaries ought to be Biofuels Marketing Licensees, whereas such a license can be acquired by EU-based Biofuels Producers or by EU-based Limited Liability Corporations (SAs) which are actively contracted with EU-based Biofuels Producers within or outside Greece, for the purchase of biofuels or other renewable fuels. The Biofuels Marketing Licensees can produce or import biofuels and other renewable fuels and provide them locally to Refiners, Oil Marketing type A Licensees and end consumers. In the case of liquid biofuels destined for blending with crude oil products, the Biofuels Marketing Licensees can only provide them to Refiners or Oil Marketing type A Licensees. Biofuels Marketing Licensees must also have adequate storage capacity of 100 cubic meters per minimum for storing pure biofuels or other renewable fuels.

Allocation Determination

This particular leg of the Biodiesel Allocation Program incorporates the most complex process. In order to determine the final allocation per beneficiary, the criteria below are taken into account:

1a) Current purchase contacts of raw materials for the production of pure biodiesel within Greek territory from energy crops of Greek origin.
1b) Invoices and / or accounting records of purchases of cotton seed and / or seed oil.
1c) Invoices of raw materials from used vegetable oils, cooking oil and animal fat of Greek origin, qualified for the production of biofuels.
2) The capacity of the EU-based Biodiesel Plant or the import contracts of biodiesel from Biodiesel Plant installed in other EU member state.
3) The existence or non-existence of biodiesel production and distribution ISO 9000 Certificate.
4) The maximum offered premium from the candidate beneficiary, which represents the total production cost and profit margin in € per 1.000 litres on top of the reference price. The reference price is the average of the "Reuters Biodiesel ex Works" quotation (under column FAME2 Germany) and of the low price of "Biodiesel" for the winter period. For the summer period, the reference price is quotation "FAME0" (under column Barges FOB Rotterdam). These quotations are published by the Platt's European Marketscan.
5) Current cooperation agreements between the candidate and research centres or participation in research programs within the EU, related with biofuels and biomass.
6) Sum of pure biodiesel deliveries, in cubic metres, from the allocation of the last two years.
7) Performance indicator of delivering pure biodiesel to refineries during the last year.

All the above parameters are incorporated in the following formula which quantifies with weighted factors the contribution of each parameter and calculates the allocated biodiesel quantity per beneficiary in 1.000 litres:

Ki = { [0,25 * ΕΛ1i / (Σύνολο ΕΛ1i)1 + [0,05 * ΕΛ2i/ (Σύνολο ΕΛ2i)]+ [0,075 * ΕΛ3i / (Σύνολο ΕΛ3i)] + [0,20 * Ai / (Σύνολο Ai)] + [0,05 * Ii / (Σύνολο Ii)] + [0,10 * Ti / (Σύνολο Ti)]+ [0,05 * Ei / (Σύνολο Ei)] + [0,15 * Πi/ (Σύνολο Πi)] + [0,075 * ΠΚi/ (Σύνολο ΠΚi)]} * Total Allocated Quantity[64]

Following the completion of the allocation process, a joint ministerial decision (JMD) of the same ministries as of the abovementioned committee, is issued yearly by the 1st of June latest, approving the pure biodiesel allocation quantities per beneficiary and setting binding monthly delivery schedule.

The table below comprehends the allocation per beneficiary for 2015:

[64] For more information please refer to the article 22 of Law 3769/2009.

Table 6. Allocation per beneficiary for 2015

Nr	Title of Beneficiary Company	Total Annual Allocated Quantity of Pure Biodiesel (thousand litres)	Allocation Quota Per Beneficiary (%)
1	BIONTIZEL L.T.D.	5.238,461	3,74%
2	BIOENERGIA	3.714,413	2,65%
3	AGROINVEST S.A.	32.635,934	23,31%
4	ECCOCISTIRIA CLOSTIRIA VOREIOU ELLADOS S.A.	788,303	0,56%
5	PETSAS S.A.	756,303	0,54%
6	STAFF COLOUR–ENERGY S.A.	4.254,343	3,04%
7	PAVLOS N. PETTAS S.A.	23.495,793	16,78%
8	MIL OIL HELLAS S.A.	7.143,903	5,10%
9	NEWENERGY S.A.	13.305,647	9,50%
10	ELIN BIOFUELS S.A.	14.094,766	10,07%
11	AVIN	1.439,866	1,03%
12	MOTOR OIL HELLAS CORINTH REFINERIES S.A.	2.746,087	1,96%
13	MANOS S.A.	7.355,529	5,25%
14	HELLENIC PETROLEUM S.A.	1.228,345	0,88%
15	TAILOR' S ENERGIAKI S.A.	1.818,384	1,30%
16	TAILOR' S CONSULTANTS & COLOURS L.T.D	1.818,384	1,30%
17	REVOIL BIOFUELS S.A.	931,734	0,67%
18	GF ENERGY S.A.	17.233,802	12,31%
	TOTAL	**140.000,00**	**100%**

Source: FEK 911 B (19/05/2015), Allocation of 140.000 thousand litres of pure biodiesel for 2015, according to the provisions of art. 15A par. 7 of Law 3054/2002

Bioethanol

The bioethanol in Greece is overall in an extremely primitive stage. Despite the fact that the European legislation, which is transposed in Greek legislation, is not limited only to biodiesel when referring to biofuels, no specific policies promoting the production or use of bioethanol in Greece have been in effect. In fact, until nowadays, not even one litre of bioethanol has been produced in the Greek territory and no related investments are known to be undergoing.

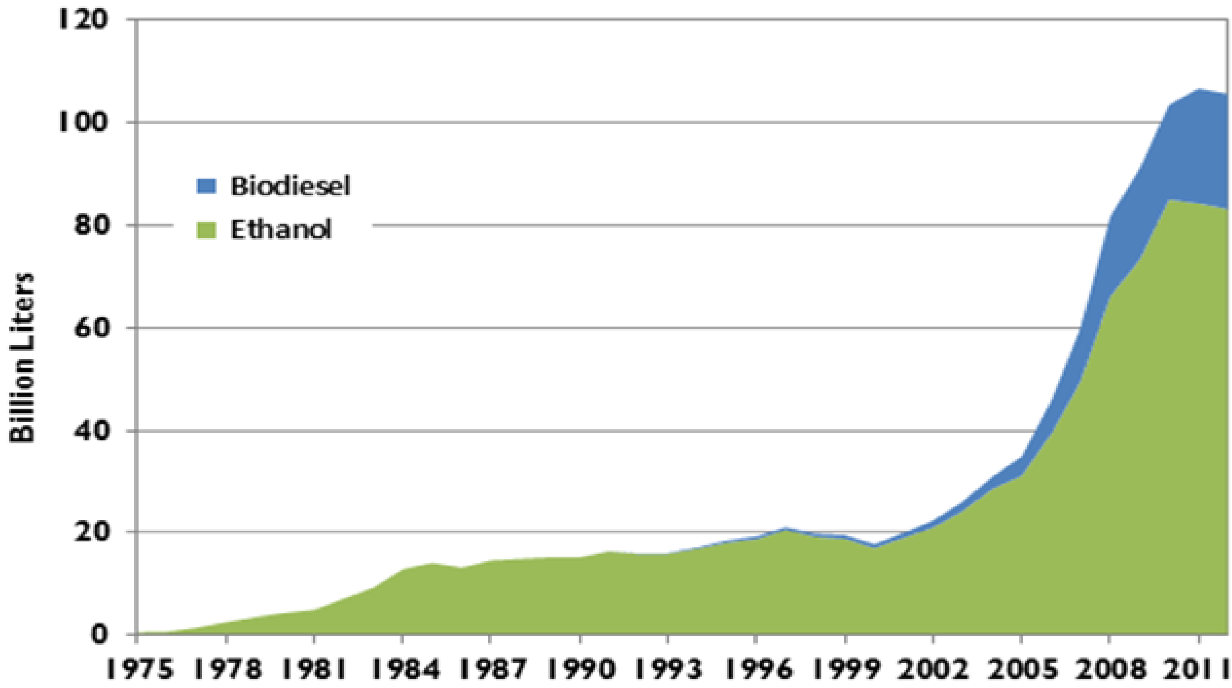
Only recently, in August 2013, technical regulation (D3/A΄/oik.15225) regarding the storage and distribution of biofuels was published prescribing the proper way to store, blend and distribute apart from biodiesel, bioethanol as well. It is worth noting that due to the fact that the bioethanol is very sensitive to any presence of water, whose incidence is frequent in the supply chain of fuels, it is recommended by the regulation to blend bioethanol with gasoline at terminal and depots or refinery truck filling stations, so as to be as close as possible, in terms of storage time, to the retail fuel stations. Furthermore, the regulation suggests that the blending process should take place in specially insulated storage tanks (not in tanks with external floating cover, as most gasoline storage tanks in Greece have), or in the tank trucks during loading at the filling station of the depot or refinery.

Chapter 2: Market Analysis

2.1 Biofuels market analysis in general

The first decade of the 21st century was by far the golden era of biofuels, as their production and consumption soared all over the world. From 2000 until 2010, the world's production increased more than 500%.

Figure 10. World Ethanol and Biodiesel Production, 1975 - 2012



Source: Worldwatch Institute (2014), F.O. Licht, RENZI

The combination of high fuel prices, the allure for a greener future and the generous regulatory support had been driving investments in the biofuels industry at a very high speed.

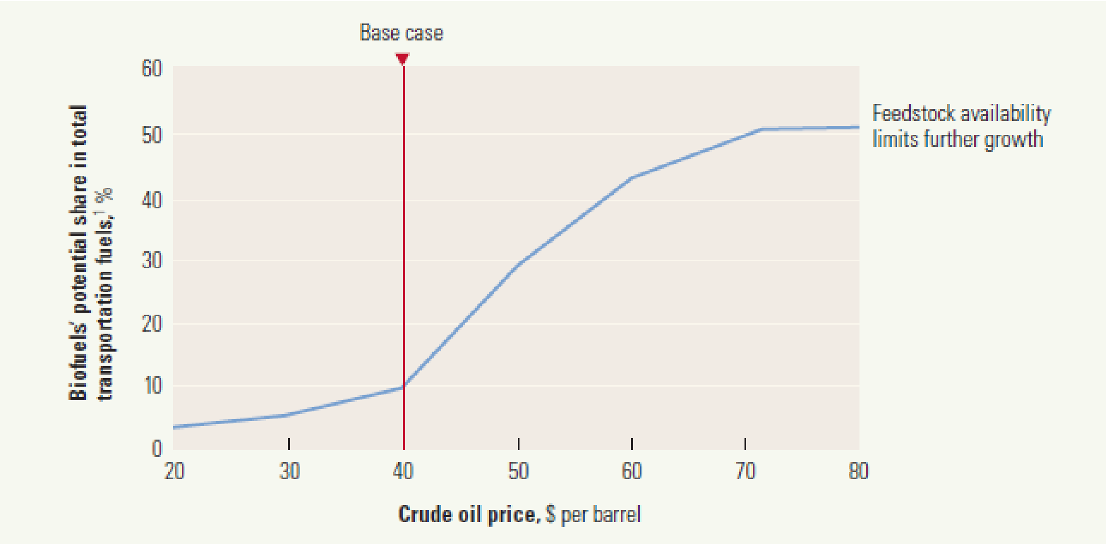
However, this dynamic is not currently maintained. In 2012, the combined global production of ethanol and biodiesel fell for the first time since 2000, down 0.4 percent from the figure in 2011.[65] As McKinsey's principals Bill Caesar, Jens Riese and Thomas Seitz noted already in 2007, while billions were pouring into biofuels, the biofuels business was starting getting surrounded by increased uncertainty. According to their analysis, the variables that directly influence the profitability and environmental impact of biofuels are the fuel prices, the cost and availability of feedstock, the government regulation and the conversion technologies and are all significantly interrelated.[66] Obviously, the way that the above factors will be

[65] Prugh, T., (2014), Biofuel Production Declines, Worldwatch Institute, Washington, USA
[66] Caesar, B. et al, (2007), Betting on biofuels, The McKinsey Quarterly, p.53-63, McKinsey & Company, New York, USA

developing depending on each other will determine the result of an investment in biofuels nowadays.

McKinsey's analysis goes beyond and introduces imponderables into a supply and demand model trying to predict the potentials of the biofuel industry. This model is partially exhibited in the following figure, where the curve of the biofuels potential share in total transportation fuels and the crude oil price are evolving together. The higher the price of crude oil, the greater the penetration of biofuels in the transportation sector, until a certain level naturally, when the availability of feedstock will be constraining any further growth.

Figure 11. Impact of crude oil prices on economic-replacement potential of biofuels



Source: Caesar, B. et al, (2007), Betting on biofuels, The McKinsey Quarterly, p.59, McKinsey & Company, New York, USA

2.1.1 Marketing

From the very early years of biofuels development, the idea that the government policies ought to lead the penetration of biofuels in transportation fuels has been prevailing. Blending mandates, tax exemptions, subsidies and direct/indirect financing of different sort were thought, at least initially, to be the most appropriate measures to encourage the biofuels sector growth worldwide. However, now that biofuels markets are showing signs of maturity, such regulatory intervention is not considered sustainable in the long run.

The work of M. E. Edeseyi et al[67] suggests that the future of biofuels cannot be heavily reliant on government policies. Of course, tax exemption policies directly rewarding the biofuel-consuming public could be efficient. Yet, the authors innovate by proposing that the biofuels should be marketed as any other product and the industry should design and apply strategies customized on the specific market environment. Sustainability, being the zeitgeist of our times, can be accredited to biofuels with great success, as they are renewable, cleaner, considered to harm the environment much less than fossil fuels and overall quite satisfactory in terms of transportation efficiency. Therefore, some consumers would even pay a premium for them, without the driving force of state regulations. According to the authors, in order to revitalize the market of biofuels and explore better their potential, the biofuel products have to be reassessed using the 4 P's, product classification, pricing, place and promotion marketing methodology:

Product Classification

The segmentation of the market and the standardization of different options of biofuels such as light and heavy products, as with oil commodities, for the ease and reassuring of consumers, since many different choices tend to create confusion, will enable targeted and more successful marketing strategies.

Pricing

While biofuels should always bear competitive pricing with oil based fuels, the incorporation of green marketing strategies which will be selling the biofuels' unique sustainability values could help control the many uncertainties of the supply chain various costs, such as transportation cost, tariffs, import duties, exchange rate fluctuations and high production costs.

Place

Minimizing geographic distances between farms and refining plants, investigating the best feedstock resources, optimizing the logistics of the supply chain, all in the light of green distribution strategies are key issues for the implementation of profitable marketing strategies.

Promotion

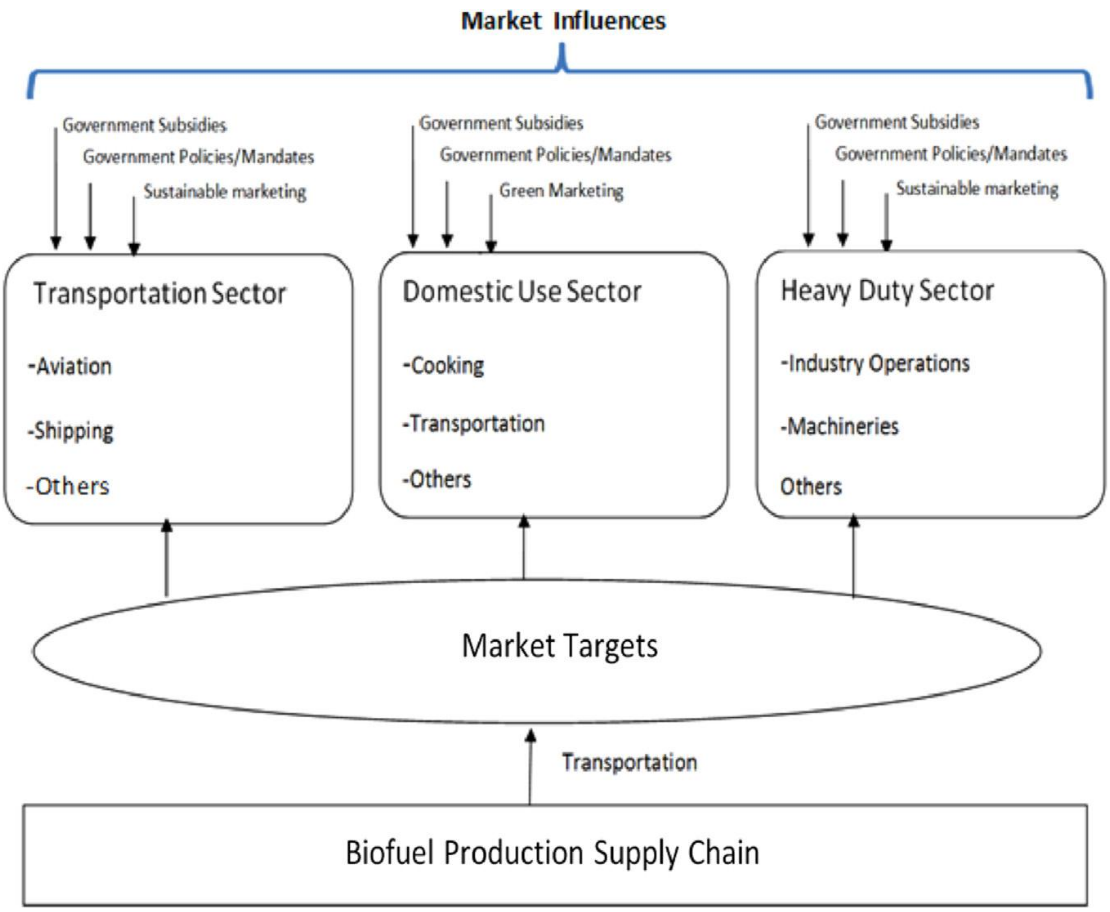
To promote customers' awareness of the biofuel products, advertising and publication marketing activities aimed to desensitize misconceptions and wrong information as well as to highlight the intrinsic features of biofuels should be applied not only to large companies in order to motivate them invest in biofuels but also to end use consumers.

---

[67] Edeseyi, M. E. et al, (2015), Rethinking sustainable biofuel marketing to titivate Commercial interests, Renewable and Sustainable Reviews, Vol. 52, p781-792, Elsevier, Amsterdam, The Netherlands

Prior to applying the aforementioned marketing methodology efficiently to specific segments of the market, the biofuels stakeholders should be able to map the biofuel topography, starting from the production supply chain, then heading to specific market segments, identifying in parallel the most appropriate policy / marketing mix for each area of interest. The following figure from the work of Edeseyi et al offers such opportunity explicitly.

Figure 12. Biofuel production supply chain and target markets categorization[68]



Source: Edeseyi, M. E. et al, (2015), Rethinking sustainable biofuel marketing to titivate Commercial interests, Renewable and Sustainable Reviews, Vol. 52, p789, Elsevier, Amsterdam, The Netherlands

It is worth noting here that apart from the traditional road transportation sector which almost engrosses the production of biofuels worldwide, significant opportunities are beginning to emerge having to do with the aviation and marine sector.

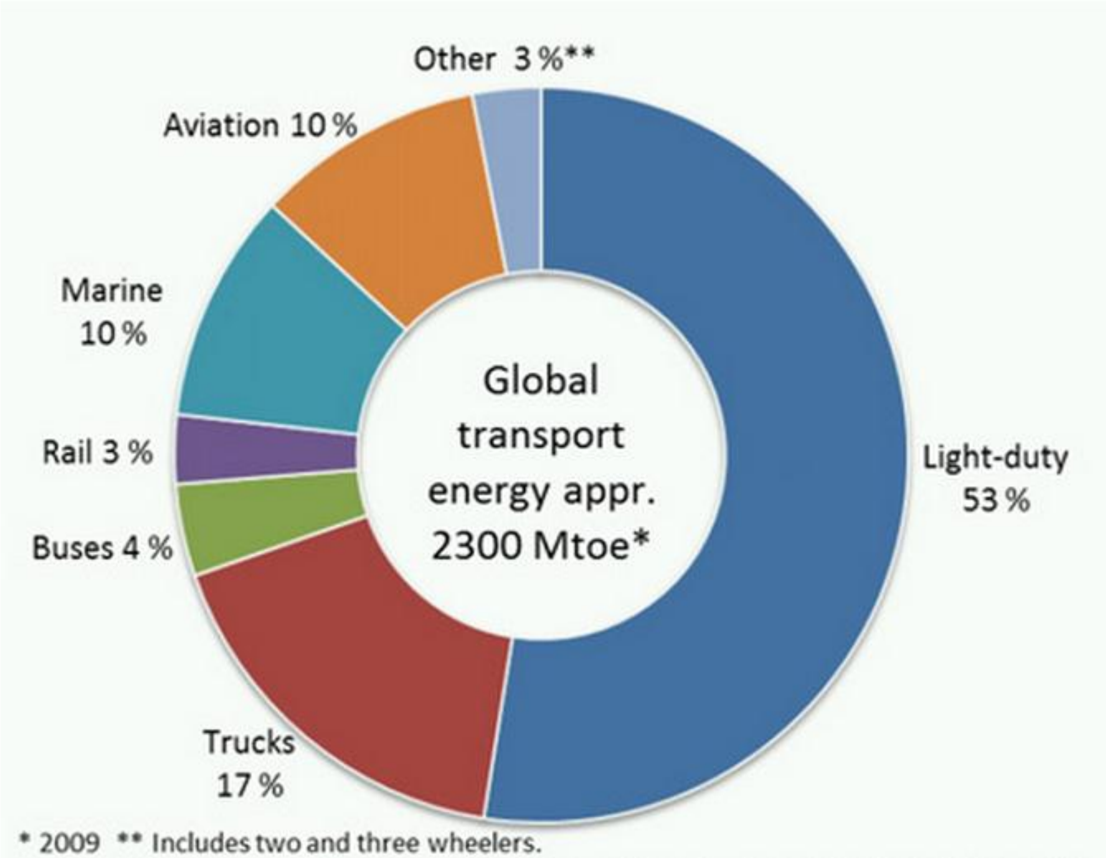
Aviation Sector

In July 2011, the world widely accepted U.S.-based technical-standards group, ASTM International, granted airlines the final approval to power their jets with a blend made from traditional kerosene and biofuels derived from inedible plants and

68

organic waste, revising and publishing the standard ASTM D7566 (Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons). In short, the conventional jet fuel can contain up to 50 percent bioderived synthetic blending components.[69] Considering that global aviation accounted in 2009 for the 10% of global energy in the transport sector, the aviation perspective of biofuels appears to be colossal.

Figure 13. 2009 Global Transport Energy Distribution



Source: EBTP (2015), Biofuels for Air Transport: Biofuels in Aviation - An Overview, European Biofuels Technology Platform, http://biofuelstp.eu/aviation-biofuels.html, EU

Airline carriers being major energy consumers are at the same time major greenhouse gases emitters. The advanced liquid biofuels are their only low-CO2 alternative for substituting the conventional jet fuel, as they can offer the high specific energy content indispensable for aviation use. Electrification is not an option for air transportation due to its energy content, nor are the first generation biofuels, due to their gaseous emissions. In the EU there are currently several initiatives aiming to promote the use of aviation biofuels such as the European Advanced Biofuels Flight path and the FlightPath 2050: Europe's Vision for Aviation.[82]

Marine Sector

[69] ASTM (2011), ASTM Aviation Fuel Standard Now Specifies Bioderived Components, News Releases, ASTM International, http://www.astmnewsroom.org, Philadelphia, USA

Another potential major customer of biofuels in the near future is shipping. Similarly with the aviation sector, marine fuels account for 10% of global transportation energy as well. [82] Having less stringent standards for fuel quality and safety than aircrafts, ships could possibly substitute their conventional fuels (Marine Gas Oil or Marine Fuel Oil) even more easily. Although marine transport is one of the least energy intensive way of transporting goods, however, it is also one of the sectors with the fewest available alternatives to fossil fuels. In order to tackle global warming, all industrial sectors should take measures to cut emissions and biofuels can help achieve this in the marine transport sector.[70] However, no ASTM standards for marine applications have been approved yet and skepticism about certain characteristics of biodiesel potentially affecting safety in marine applications such as inconsistent quality, lack of marine standards, and impact on fuel system components such as engine seals, engine manufacturer's warranties, disadvantageous hydrophilic properties, cold weather flow drawbacks, and the ability to remain stable in a marine environment over a period of time, is still ongoing.[71]

Sustainable Marketing

Having its roots in 1970s, when the idea of integrating concern into the practice and principles of marketing started to formulate, the sustainable marketing is a direct descendant of green marketing theories.[72] Being a marketing practice predicated upon the commitment to avoiding depleting and degrading the environment, while reducing waste, energy consumption, protecting the merchandise brand by anticipating needs based upon and arising from expectations of longevity in a market, sustainable marketing is a perfect match for biofuels. It could offer to biofuels the indispensable innovation advantages to go beyond the traditional demand – supply continuum and gain attractiveness for current and new markets.[73]

2.1.2 Pricing

Analyzing the end price of any particular biofuel is a very difficult task, as they depend on a complex mixture of factors that are often affected from and influence each other such as: costs of various types of feedstock, production volume, production process, tax and other incentives, food prices, transportation costs, research investment, business targeted margins and more. Not only do the prices vary from country to country, just as they do with petroleum products, they also vary

[70] Opdal, O.A. & Hojem, J.F., (2007), Biofuels in ships, p. 10, ZERO, Oslo, Norway
[71] Nayyar, P., (2010), The Use of Biodiesel Fuels in the U.S. Marine Industry, p. 78, Maritime Administration, USA
[72] Peattie, K., (2001), Towards Sustainability: The Third Age of Green Marketing, The Marketing Review, Vol. 2, Number 2, p. 129 – 146, Westburn Publishers, Helensburgh, Scotland, UK
[73] Edeseyi, M. E. et al, (2015), Rethinking sustainable biofuel marketing to titivate Commercial interests, Renewable and Sustainable Reviews, Vol. 52, p. 790, Elsevier, Amsterdam, The Netherlands

significantly depending on each particular biofuel type and generation in terms of technology (first generation or advanced one etc.). Nevertheless, a broad idea of how biofuels prices are compared with the prices of petroleum products in terms of cost can be determined.

In general, most enterprises and countries intend to hold the end price ("price at the pump") of biofuels at or near the price of petroleum fuels. Interestingly, maintaining costs before 2005, when crude oil was traded below 50 USD per barrel, was not possible. From 2005 until 2014, when the price of fossil fuels rose dramatically, biofuels became attractive and blossomed worldwide. But even during that period, government subsidy was often necessary to make biofuels fully competitive. From October 2014 until nowadays, the falling fossil fuel prices challenge again the competitiveness of alternative fuels and probably maintain the call for state support actions.

Figure 14. West Texas Intermediate Crude oil spot prices in US Dollars per barrel from 2000 until 2015 Jan 2016

Source: http://www.economicgreenfield.com

2.1.3 Price Transmissions

The food versus fuel debate, also approached in §1.1.2, can be defined as the dilemma regarding the risk of diverting farmland or crops for biofuels production to the detriment of the food supply, and has been a long standing and controversial throughout the literature. In this section, we are examining the price transmissions between biofuels and food commodities, through three very recent academic papers (of 2013, 2014 and 2015), which apply econometric methodologies to arrive in quantitative conclusions.

Nicholas Apergis and Dimitris Voliotis (2013): Spillover effects between fossil energy prices and non-energy commodity prices: further evidence from world spot markets[74]

In their empirical study, Apergis and Voliotis investigate the extent of fossil energy prices, i.e. oil, coal and natural gas, and a sample of 18 non-energy commodity prices' interlinkages, as well as the causal structure of the impact of fossil prices on non-energy (agricultural) commodity prices. The novelties of this study comprise the inclusion for the first time of coal and natural gas prices, apart from the prices of oil that have been traditionally examined in the literature and again for the first time, according to the authors, their study includes the majority of non-energy commodities, contrary to previous works which only include a subset of those commodities. The paper employs the methodology of long and short-run causality approach as well as the methodology of the error correction model based on daily prices.

The empirical findings illustrate that the long-run estimations for all three types of fossil energy prices generate the same results implying that all three fossil energy prices are important factors for the course of non-energy commodity prices in the long-run, while the impact of oil prices on those commodities is more pronounced than that of coal and natural gas in all cases, except the cases of sunflower oil, wheat, camelina oil and cacao. Moreover, the authors conclude that the link between traditional (fossil) energy markets and commodity markets gets stronger, creating serious implications for producers, policy makers, traders, and food and energy security. Although the growth of renewable fuels industry, biofuels in our case, reveals new opportunities for agricultural and other commodity producers, one should not overlook the introduction of new sources of risk, as the market prices of agricultural commodities may become more dependent on fossil energy prices. The fact that causality lies between energy and non-energy commodities implies informational benefits across markets, leading to stronger energy and crop portfolio diversification, better forecasting ability, and, potentially, to higher profits.[75]

Bernardina Algieri (2014): The influence of biofuels, economic and financial factors on daily returns of commodity futures prices[76]

In her study, B. Algieri examines the impact of biofuels on corn, rapeseed, soybean, soybean oil, sugar and wheat futures returns, using GARCH (Generalized Autoregressive Conditional Heteroskedasticity) family models and controlling for financial and economic factors, such as the Standard & Poor's 500, crude oil, the U.S.

---

[74] Apergis, N. and Voliotis, D. (2013), Spillover effects between fossil energy prices and non-energy commodity prices: further evidence from world spot markets, Int. J. Global Energy Issues, Vol. 36, Nos. 5/6, p. 293 – 311

[75] Cooke, B. and Robles, M., (2009), Recent Food Price Movements: A Time Series Analysis, IFPRI Discussion Paper, No. 00942, IFPRI, Washington DC, USA

[76] Algieri, B., (2014), The influence of biofuels, economic and financial factors on daily returns of commodity futures prices , Energy Policy, Vol. 69, p. 227 - 247, Elsevier, Amsterdam, The Netherlands

dollar/euro exchange rate, and monetary liquidity variables such as the Outstanding Open Market Operation by the ECB (European Central Bank) and the Lending Rate by the FED (Central Banking System of the United States). This study contributes to the existing literature mostly due to the introduction of the parallel monitoring of the monetary policy through the above monetary liquidity variables, while investigating the price effects between energy and agricultural markets. The majority of existing studies does not take into account other control variables, such as the monetary ones.

Summarizing the results of this study, first of all, energy policies such as mandates, targets and subsidies that support production of biofuels should be carefully monitored, and some biofuel programs should be redesigned in order to avoid or reduce the fuel versus food conflict. Secondly, there is a shift in focus from first-generation to second-generation or advanced biofuel technologies. In any case, multiple and complex interactions between factors are existent and so are drivers which influence each other through various linkages and feedback loops. For instance, the link between energy and non-energy commodities is much more complex and broad, with a number of additional dimensions such as high energy intensity of most agricultural commodities, transmission elasticities that may change overtime, and likely spillover-effects from crude oil to non-energy markets through investment fund activity. Regarding the effect of stock markets in commodity prices, the statistical significance of the Standard & Poor's 500 illustrates the magnified effect of the stock market returns on commodity price returns, which is stronger for the sugar, wheat and soybean oil markets. With reference to the exchange rate variable, it is always significant and negatively linked to commodity markets. Finally, the results have shown that the monetary policy does not influence the commodity returns on a daily basis. Although there is no daily influence, a positive long run relationship between global liquidity and the development of food commodity price returns cannot be scored out, as generally, the monetary policy schemes do not have an immediate effect on the economy but rather a medium or long term one. Conclusively, the spillover effects between energy prices and corn, wheat, sugar and soybeans, which are the main feedstock of first generation biofuels, indicate that biofuel policies should be closely monitored and probably altered in order to save resources from unnecessary first generation biofuels subsidization.

Constantinos Katrakilidis, Moise Sidiropoulos, Nikolaos Tabakis (2015): An empirical investigation of the price linkages between oil, biofuels and selected agricultural commodities

Their work aims to move the relevant research one step further by investigating simultaneously three different groups of variables for more robust results. The dynamic linkages between crude oil and agricultural commodities, agricultural products and biofuels and between energy system and biofuels are investigated, by applying the ARDL cointegration methodology (Autoregressive-Distributed Lag). They employ monthly data from the Bloomberg's database and their variables consist of the following: corn, sugar, food price index, crude oil, ethanol and biodiesel prices.

In line with the previous papers, their results also provide evidence of cointegration between crude oil and agricultural commodities. Long run causality from crude oil to corn and sugar has been identified, as well as long run causality running from corn to ethanol. There is also evidence of long run causality from crude oil to ethanol. As regards to the short run dynamics, short run causality between crude oil and agricultural commodities, from crude oil to corn, sugar and food price index has been found. Furthermore, the results show short run causality from the general food price index to biodiesel and from crude oil to biodiesel. Concluding, the high dependence of agricultural commodities with fossil fuels is evident, implying that the threat of sudden and unanticipated rises in oil prices, which will consequently lead to rises in food prices, cannot be avoided, unless we substitute part of our oil based energy needs with alternative fuels.

2.1.4 Trading and Risk Management

One of biofuels' particularities – especially of liquid biofuels - is that they bridge the agricultural commodity markets (dry) with the oil/petroleum markets (wet). Biofuels act as an intermediate, retrieving their feedstock from the agricultural world and providing products to be blended with the fossil fuels. Nowadays, large corporations - traditionally trading agricultural commodities - have entered the biofuels business and so have done some of the world's top oil trading companies.[77]

Similar to the majority of commodities, from the beginning of their commercialization, biofuels had been trading over the counter, i.e. directly between two parties, without any supervision of an exchange and of course still do. However, during the 00s and in parallel with their global mushrooming, traditional commodity exchange markets (e.g. ICE - Intercontinental Exchange, CME Group - Chicago Mercantile Exchange, NYMEX – New York Mercantile Exchange) have incorporated biofuels in their spectrum, while new exchange markets for renewable products have emerged, offering simple and composite products, both for trading and managing the risk derived from trading in the secondary markets.

Due to the fact that the biofuels trading history is rather short, counting more or less approximately 20 years, their trading compared with other commodities lacks contract standardization and liquidity, which results in absence of commoditization. In this direction, the world's two most significant information providers for the

[77] Feeney, A., (2009), Renewables Commodity Market: Aspects of EU Biofuels Trading, RenewableEnergyWorld.com

commodities and energy markets, Platts and Argus Media are providing daily price assessments on various products of biofuels on a global level. Platts[78] reports on ethanol, biodiesel, MTBE (Methyl tertiary butyl ether — an octane booster and oxygenate used for gasoline blending, ETBE (Ethyl tertiary butyl ether - an oxygenate gasoline additive in the production of gasoline from crude oil), RINs[79] and feedstocks such as wheat, corn, sugar (including the respective freight assessments). Similarly, Argus Media reports on Biodiesel physical and paper markets, Ethanol and feedstocks such as rapeseed oil, Asian palm oil and Argentinian soybean oil, including freight assessments as well.[80]

Thereafter, it is clear that various financial products now exist ranging from the areas of feedstock (agricultural), biofuels to of course oil/petroleum, equipping investors, producers, traders and other stakeholders with tools to hedge their positions throughout the supply chain and thus limit their exposure to price fluctuations. Furthermore, there is concrete evidence that price correlations between agricultural, biofuel and oil products do exist, as mentioned in the previous paragraph. Consequently, the value of these financial hedging tools will be increasing, likewise with the majority of financial products, as the liquidity of the commodity markets increases too.[81]

2.2 The Greek case

2.2.1. Market basics and scope

The term of liquid biofuels in Greece is practically identical to the one of biodiesel. The reason is that as mentioned in $ 1.3.5, there is no bioethanol production locally nor any bioethanol imports have been performed. Despite the fact that the European legislation and regulatory framework regarding bioethanol are present, it seems that no targeted policies aiming to promote the production, import and consumption of bioethanol have taken place. We will endeavor to investigate the real causes underlying this critical discrepancy compared with other European countries in the sections to come.

The first steps were taken with the implementation of four Research and Development projects sponsored by the European Union from 1995 until 2004

[78] http://www.platts.com/products/market-data-biofuels

[79] A Renewable Identification Number (or RIN) is a serial number assigned to a batch of biofuel for the purpose of tracking its production, use, and trading as required by the United States Environmental Protection Agency's Renewable Fuel Standard implemented according to the Energy Policy Act of 2005

[80] https://www.argusmedia.com/Bioenergy/Argus-Biofuels/

[81] Stone, M., (2011), Biofuels: volatility and risk management, World Biofuels Congress, Argus Media, www.argusmedia.com

respectively, titled ALTENER[82]. Key contributors of these programs were mainly the Fuels and Lubricants Technology Laboratory of the National Technical University of Athens, Elinoil S.A., later parent company of Elin Biofuels S.A., which was established in 2005 in order to engage actively in the Greek biofuels sector and the Centre for Renewable Energy Sources and Saving (CRES - the Greek national entity for the promotion of renewable energy sources, rational use of energy and energy conservation).

In December 2005, the first biodiesel commercial volume output was produced by the company Hellenic Biopetroleum S.A. Since then, the annual quantity to be distributed for blending with diesel fuel in the Greek market is being defined by a Ministerial Decision of the Ministry of Environment and Energy[83].

In 2015, among the 18 companies which qualified as beneficiaries of the annual volume, 12 were producers and 6 importers. The 12 producers accumulated in total for the 93% of the volume, for approx. 130 thousand cubic meters (i.e. one hundred thirty million liters). However, their installed capacity is approximately sevenfold the total annual volume. It is worth noticing that the capacity of the largest producer, Agroinvest S.A., is more than double compared to the total annual volume and that the capacities of the 2nd, 3rd and 4th largest producers equal from 80 to 65 percent of the total annual volume. Thus, it is very obvious that the installed biodiesel production capacity in Greece is asymmetric to current local demand and underutilized as only 14.4% percent of it is being employed for the local market. It is also clear that there is significant potential, at least in terms of capacity, for exports and/or for serving higher blending mandates (currently the blending mandate is set at 7%). This potential can be further highlighted with the help of the following simple mathematical example.

E.g. the diesel oil consumption for road transportation of 2015 was approx. 2,900,000 cubic metres[84] (2.9 billion liters). If the Greek biodiesel production units were running at the 90% of their capacity (i.e. 90% x 901,290 cubic meters = 811,161 cubic meters) for one year, sourcing all their output for the local market, then the total biodiesel produced would suffice to be blended with diesel oil at approx. 28%.

[82] European Bioenergy Networks (2003), Liquid biofuels network: Activity Report, p. 23 – 29, France
[83] q.v. $ 1.3.5: Biodiesel Allocation Program
[84] According to IEA (International Energy Agency). Data downloaded from http://www.iea.org/statistics/onlinedataservice/.

Table 7. Allocation and Capacity per beneficiary for 2015

Nr	Title of Beneficiary Company	Total Annual Allocated Quantity of Pure Biodiesel (thousand litres)	Allocation Quota Per Beneficiary (%)	Nominal Capacity (thousand liters per annum)
1	AGROINVEST S.A.	32.635,934	23,31%	286.364
2	PAVLOS N. PETTAS S.A.	23.495,793	16,78%	112.500
3	GF ENERGY S.A.	17.233,802	12,31%	127.000
4	ELIN BIOFUELS S.A.	14.094,766	10,07%	90.909
5	NEWENERGY S.A.	13.305,647	9,50%	39.273
6	MANOS S.A.	7.355,529	5,25%	93.563
7	MIL OIL HELLAS S.A.	7.143,903	5,10%	11.363
8	BIONTIZEL L.T.D.	5.238,461	3,74%	23.958
9	STAFF COLOUR–ENERGY S.A.	4.254,343	3,04%	13.000
10	BIOENERGIA	3.714,413	2,65%	40.000
11	ECCOCISTIRIA CLOSTIRIA VOREIOU ELLADOS S.A.	788,303	0,56%	23.760
12	PETSAS S.A.	756,303	0,54%	39.600
	Subtotal of Producers (12)	**130.017,197**	**92,87%**	**901.290**
13	MOTOR OIL HELLAS CORINTH REFINERIES S.A.	2.746,087	1,96%	
14	TAILOR' S ENERGIAKI S.A.	1.818,384	1,30%	
15	TAILOR' S CONSULTANTS & COLOURS L.T.D	1.818,384	1,30%	
16	AVIN	1.439,866	1,03%	
17	HELLENIC PETROLEUM S.A.	1.228,345	0,88%	
18	REVOIL BIOFUELS S.A.	931,734	0,67%	
	Subtotal of Importers (6)	**9.982,800**	**7,13%**	
	Grand Total	**140.000**	**100,00%**	**901.290**

<u>**Source**</u>: Data retrieved from Ministry of Environment and Energy (www.ypeka.gr) and Foundation for economic & industrial research (2010), The sector of renewable fuels in Greece: issues and prospects, p.16, Athens, Greece and FEK 911 B (19/05/2015), Allocation of 140.000 thousand litres of pure biodiesel for 2015, according to the provisions of art. 15A par. 7 of Law 3054/2002

In the sections to come (§2.2.2 and §2.2.3), our analysis of the macro and micro environment of the biofuels sector in Greece will be explicated. Apart from recent literature, mainly from Greek researchers, from which we are sourcing the most expedient findings, we are also formulating positions and ideas collecting data that derive from a special research we conducted for the purposes of this dissertation. This short research was carried out through the methodology of a qualitative questionnaire which included four areas of interest – Current production technology and perspective, Current biofuels portfolio and perspective, Current market performance and perspective, Road to 2020 – and consisted of sixteen sub queries without standardized possible answers[85]. It was addressed to the Owners and Sales

[85] The full questionnaire is available in the Appendix.

Managers of the four major biofuel corporations in Greece, **AGROINVEST S.A.**, **ELIN BIOFUELS S.A.**, **GF ENERGY S.A.** and **PAVLOS N. PETTAS S.A.**, who we deeply thank for their useful contribution. The allocation quota for 2015 of this group of corporations – all of them producers – adds up to 62.5% of total allocation, while their aggregated capacity is 68.5% of total active capacity. Therefore, we believe that their positions, even if biased at some rate, are of considerable importance for the present and the future of this sector. Furthermore, we decided not to offer the possibility to answer the questionnaire through multiple standardized selections, in order not to pre-empt the research and let the aforementioned key stakeholders express their views in a free manner.

The questionnaire results and relevant literature engineer the macro and micro environment analysis which unfolds with the help of PEST and SWOT frameworks.

A common framework or tool used by marketers to analyze and monitor the macro-environmental (external marketing environment) factors that have an impact on a project, organization or sector is the PESTEL analysis. The PESTEL[86] abbreviation stands for the political, economic, social, technological, economical and legal environments that affect the subject under examination. The results of this analysis are used, among other reasons, so as to identify the opportunities and threats which contribute greatly to the analysis of the micro-environment according to the SWOT analysis rationale (initialism for strengths, weaknesses, opportunities and threats of the analysis of a product, project or industry). The PESTEL and SWOT methods of analysis share a history of sixty years more or less. Harvard professor Francis Aguilar is thought to be the creator of PEST Analysis. In his 1967 book, "Scanning the Business Environment", he included a scanning tool called ETPS, the name of which was later tweaked to create the acronym of PEST, that quickly obtained a lot of variations, the mostly applied being the PESTEL one[87]. The SWOT analysis which frequently follows a PEST analysis, seeks to address the question of strategy formation from a two-fold perspective: from an external appraisal (of threats and opportunities in an environment) and from an internal appraisal (of strengths and weaknesses in an organization)[88]. Some authors credit SWOT to Albert Humphrey, who led a convention at the Stanford Research Institute (now SRI International) in the 1960s and 1970s using data from Fortune 500 companies. In fact, it is believed that the SWOT analysis framework started its "career" being titled as SOFT (Satisfactory - good in the present, Opportunity - good in the future, Fault - bad in the present, Threat - bad in the future)[89].

---

[86] Kim – Keung Ho, J., (2014), Formulation of a Systemic PEST Analysis for Strategic Analysis, European Academic Research, Vol. 2, Issue 5, Hong Kong, China

[87] www.mindtools.com/pages/article/newTMC_09.htm

[88] Karppi, I. et al, (2001), SWOT-analysis as a basis for regional strategies, Nordregio (the Nordic Centre for Spatial Development) Working Paper 2001:4, ISSN 1403-2511, Stockholm, Sweden

[89] https://rapidbi.com/history-of-the-swot-analysis/

2.2.2 The Macro-Environment analysis

PESTEL framework: Analysis of the external factors which affect the Greek biofuels industry

Following the illustration of each factor, a marker (+) or (-) will indicate its potential positive or negative effect.

Political Environment:

1. Since 2009 and in the light of Greek' s greatest economic recession of the last 50 years, we have been witnessing a turbulent political environment, with short lived governments and external institutions (European Union, European Central Bank, International Monetary Fund) having a key role in the control of the economy. Consequently, legislation and policies are often changing directions. This **political uncertainty** is definitely **increasing the entrepreneurship risk** for any kind of business in the country. **(-)**
2. The **energy and climate change** are ranked with high **priority on the policy agenda** of the European Union and its Member States. Further from the 2020 objectives, the agreement on the 2030 climate and energy framework has defined the European Union (EU) commitment of an at least 40% domestic reduction in greenhouse gas emissions compared to 1990. Thus, many countries plan to make the utmost use of their renewable energy industry potential to reduce greenhouse gas emissions, mitigate climate change and comply with the 2030 targets[90]. **(+)**
3. **Energy security** obtained through the diversification of energy sources, suppliers, supply chains, networks and exploitation of alternative methods remains **high in the political agenda of the EU, upgrading the evaluation of renewable energy**. **(+)**
4. **Political pressure** exercised on governments from parties and organizations **opposed to the use of land for cultivation of energy crops** instead of for food, influences policy planning and adaptation. **(-)**
5. **Energy power games** globally between the historical leaders (e.g. members of OPEC – Organization of the Petroleum Exporting Countries, Russia), new independents (USA due to the recent shale oil and gas revolution is claiming again its energy independence), new global powers (China mainly and India) and other regional players, will be manipulating and **changing** to an extent **the price of fossil fuels**, even if the supply and demand resources merely alter. These price fluctuations will keep **challenging the trend of investment in renewable energy**. **(-)**

[90] European Union (2015), A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, Brussels, 25.2.2015 COM, 80 final Energy Union Package Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, Comm. Of Regions and European Investment Bank

Economic Environment

1. Greece economy has yet to manage to turn page and begin growing again. The longer this highly anticipated change delays, the **lesser** the **confidence of business stakeholders in Greek economy gets**. The basic 2015 economic indicators of GDP growth rate at 0.1%, unemployment rate at 23.96%, inflation rate at -0.5% and government debt to GDP rate at 179% unveil the stagnant state of the economy[91]. **(-)**
2. **Oil prices** which are currently at their ten year lowest level **will be extensively creating barriers for biofuels**. Liquid biofuels are very easily compared with gasoline and diesel/gas oil, in terms of pricing. E.g. 100 liters of automotive diesel oil in Greece contain 93 liters automotive diesel oil and 7 liters biodiesel. Provided that the biodiesel price is higher than the automotive diesel oil price (which is the case nowadays), then the biodiesel is responsible for more than 7% of the cost of the end product. **(-)**
3. **Price transmissions between feedstock, food and biofuels** will be blurring the economic attractiveness of biofuels. Farmers, watching food prices rise on one hand will be reluctant to turn to energy crops production, while on the other hand governments will continue to support the use of biofuels financially through subsidies and other incentives, creating a dilemma for the agricultural sector[92]. **(-)**
4. Again due to the prolonged **poor performance of the Greek economy and the very high debt rate** (179 percent of GDP in 2015[93]), investors (internal or external) **do not** currently **favor** entering the Greek market, therefore any further **investment** in biofuels either for new business or for modernization/optimization of the existing one will probably defer. Moreover, given the circumstances, **bank financing** of investments or running business is rather **complicated**. **(-)**

Social Environment

1. The country is facing a **demographic issue**, as the current population of 11.08 million people is expected to decrease at 10.71 million people by 2030. The **population is** clearly **aging** as the 2.327 million people under 15 years old currently will fall to 1.909 million by 2030, whereas people over 65 years old counting 2.222 million in 2015 will rise at 2.606 million by 2030[94]. In this respect, the total energy demand for automotive fuels would normally decline.

---

[91] http://www.tradingeconomics.com/greece/indicators

[92] Paschalidou, A. et al, (2016), Energy crops for biofuel production or for food? - SWOT analysis (case study: Greece), Renewable Energy, Vol. 93, p. 636 – 647, Elsevier, Amsterdam, The Netherlands

[93] http://www.tradingeconomics.com/greece/government-debt-to-gdp

[94] http://www.ifs.du.edu/ifs/frm_CountryProfile.aspx?Country=GR#Population - International Futures (IFs) forecasting system and the Pardee Center for International Futures at the University of Denver

Adding up the evolving **energy efficiency** effect, the **demand for fuels will** probably be **reduced. (-)**

2. Public with growing environmental concern and increased awareness regarding energy sources, sustainability and globalized issues such as the climate change will tend to spend on renewables more and demand from policy makers to act accordingly[95]. **(+)**

Technological Environment

1. As mentioned above in social factor 1, the energy efficiency effect that is rapidly developing due to the technology advancing, will be limiting the demand for fuels overall. **(-)**
2. The development and commercialization of alternative transport technologies, such as electric, solar, CNG, Hydrogen vehicles etc. will absorb market share from compatible fossil fuels, downsizing the potential market for biofuels. **(-)**
3. Technology advances will improve the first generation biofuels processes, enabling the current installations to perform better. **(+)**
4. Technology advances both in biofuels and vehicles technology will convince the governments and communities to implement higher blending mandates. **(+)**
5. Technology advances regarding the second generation biofuels will help the current installations in adapting them and develop through as well, overcoming partially of fully the drawbacks of first generation biofuels. **(+)**

Environmental Status

1. The latest United Nations Climate Change Conference held in Paris 30 November to 12 December 2015 led to the agreement between the 195 participating countries to reduce their carbon output "as soon as possible" and endeavor their best to hold “the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C”.[96] All types of renewable energy including biofuels will contribute in this effort. **(+)**
2. Even though the world has managed to survive many peak oils that have been forecasted since the 1950s[97] and new technology breakthroughs in the production of unconventional oil and gas are constantly prolonging the next peak oil, it is widely understood that oil and gas will not be available forever at

---

[95] Mitkidis, G., (2015), MBA Dissertation: Feasibility of 2nd Generation Biofuels in Greece, p. 39, Hellenic Open University, Patras, Greece

[96] United Nations Framework Convention on Climate Change (2015), Adoption of the Paris Agreement, Framework Convention on Climate Change, Conference of the Parties, 21st session, p.2, United Nations, Paris, France

[97] Bentley, R.W., (2016), A Brief History of Forecasting Peak Oil, Introduction to Peak Oil p. 57 – 69, Springer International Publishing, Cham, Switzerland

the costs we have known them during the past 100 years. In this perspective, the transition towards renewable energy is being reinforced. **(+)**

Legal Environment

1. The evolving implementation of carbon emission trading schemes and the continuous growth of emission rights trading markets will offer potential to biofuel sellers to improve their competitiveness by accumulating CO_2 emission permits, led by the least emitters i.e. the players involved in the advanced generation biofuels.[98] **(+)**
2. The Paris Climate Change Agreement which will be ratified on 22 April 2016 by more than 130 countries will require from each country to set a specific target for the emission reduction. It is then anticipated, that the accordant countries will proceed with adopting specific legislation frameworks in order to achieve the prevailing target, in favor of renewable energy. **(+)**

2.2.3 The Micro-Environment analysis

SWOT framework: Analysis of the strengths, weaknesses, opportunities and threats of the Greek biofuels industry

Strengths

1. Development of agricultural economy and rural areas. The cultivation of energy crops is already a strong driver for the agricultural economy. According to GF Energy S.A., approximately 25,000 farmers (with their families too) are involved in the energy crops business earning more than 60 million euros per annum. Moreover, the abandoned farming lands in Greece are estimated at 6 million acres. If used for energy crops production, then the number of employed people in this primary sector could reach 340,000 contributing in country's GDP by roughly 1 billion euros yearly.[99]
2. In addition to the generation of direct employment in the agricultural world, biofuels have a positive effect creating direct and indirect jobs throughout the supply chain from the farmland to the fuel retail station. These jobs have to do principally with logistics, production and trading such as transport and storage of the feedstock, production and storage of biofuels, transport and blending of biofuels with diesel/gasoline etc.[100] Creating employment in an economy such

---

[98] Mitkidis, G., (2015), MBA Dissertation: Feasibility of 2nd Generation Biofuels in Greece, p. 40, Hellenic Open University, Patras, Greece

[99] Paschalidou, A. et al, (2016), Energy crops for biofuel production or for food? - SWOT analysis (case study: Greece), Renewable Energy, Vol. 93, p. 640, Elsevier, Amsterdam, The Netherlands

[100] Domac, J. et al, (2005), Socio-economic drivers in implementing bioenergy projects, Biomass and Bioenergy, 28(2), p. 97 – 106, Elsevier, Amsterdam, The Netherlands

as the Greek one, which has flirted with unemployment rates of 20% and more for at least five consecutive years is considered a sine qua non action.

3. A traditional stronghold of biofuel supporters globally is the claim that biofuels help reducing the emission of greenhouse gases, due to the fact mainly that through the growth of the feedstock they sequester carbon dioxide (since CO_2 is absorbed by the plants during photosynthesis). However, there are other analyses showing that the process of producing first generation biofuels may instead of contributing to carbon dioxide savings, lead to increase greenhouse emissions compared to fossil fuels, highlighting the value of developing advanced generation of biofuels.[101]
4. The reinforcement of energy security via the diversification of energy resources, independent from fossil fuels is one of biofuel key dimensions. Together with the other renewable energy sources, they drive our economy and society one step further from fossil fuels.[102]

Weaknesses

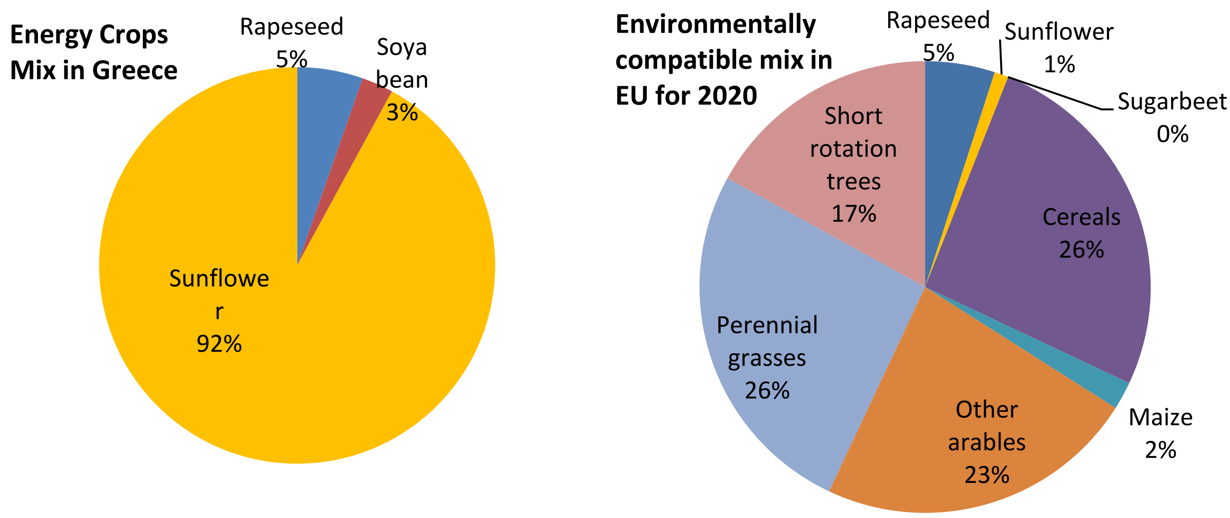
1. As highlighted before ($1.3.5 and $2.2.1) biofuels in Greece are limited to biodiesel. No bioethanol infrastructure exists whereas to build such, would require extensive capital investment and significant time. According to various references from projects globally, the cost would be some tens of million euros and five years for completion seem certain. For example, the average-sized ethanol plant in USA in 2005 cost approximately 65 million US dollars.[103] The majority of the biofuel producers of the questionnaire were reluctant or negative in view of getting involved in bioethanol. Besides the magnitude of the required investment, they are puzzled or discouraged from the following factors: a) bioethanol feedstock in Greece are from limited to rare, b) legal framework is from absent to primitive, c) technical problems arise regarding bioethanol storage, transport and blending with gasoline due to local climate and Greek geographical relief (many islands with low consumptions respectively).
2. The biodiesel cost in Greece for the end consumer is significantly high compared to the cost of the conventional diesel. The biodiesel premium that Hellenic Petroleum Refineries and Motor Oil Refineries included in their pricing of diesel blended with biodiesel in the beginning of 2016 was approximately 65 € per cubic meter. Biodiesel is blended at 7%, so it is presumed that the biodiesel pricing of the refineries was 65 / 0,07 € per cubic meter (1,000 liters), i.e. approx. 928 € per m3. On 8th of April 2016, the average refinery price, which

[101] Searchinger, T. et al, Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change, Science Vol. 319, Issue 5867 p. 1238 – 1240, Washington DC, USA
[102] Siddiqui, S. et al, (2016), Determining energy and climate market policy using multiobjective programs with equilibrium constraints, Energy, 94, p. 316 – 325, Elsevier, Amsterdam, The Netherlands
[103] Jennings (2005), The Case For Ethanol, www.forbes.com

incorporates the biodiesel premium was 341 € / cubic meter.[104] In theory, without the biodiesel addition and its respective premium, the refinery price would be approx. 275 € / cubic meter. Despite the fact that absolute price comparisons ought not to be made, because the various cost elements and profit margins cannot be identified, it is remarkable that there is a very significant discrepancy between the hypothetical prices of unblended diesel and biodiesel.

3. The energy crops mix of Greece includes only three different kinds and is dominated by one, the sunflower. The "environmentally compatible" energy crops mix which has been developed by the European Environmental Agency in view of 2020 contains larger variety and a much more equal distribution between different crops. Thus the local energy crops mix is in total inconsistence with the European Union's strategy of sustainability and environmental compatibility.

Figure 15. Energy Crops Mix in Greece in 2013 and Environmentally compatible mix for energy crops for 2020 by EEA



Source: Greek Payment Authority of Common Agricultural Policy (OPEKEPE) (2013) & European Environment Agency (2013), http://www.eea.europa.eu/data-and-maps/figures/mix-of-energy-crops-200620132008

4. The risk of land use change: In line with the global trend, areas in Greece could also be used for the cultivation of energy crops instead of food, causing shortages in the market which increase food prices either directly or indirectly through imports that replace such shortages.
5. Biodiversity and ecosystems can be endangered in case the demand for biofuels is robust. Higher yields will eventually require more land to plant energy crops into, possibly displacing established natural ecosystems and possibly damaging the soil, air and water provided that intensive agricultural

[104] http://www.fuelprices.gr/files/EBDOM_DELTIO_08_04_2016.pdf

practices are deployed. Furthermore, the practice of monoculture which is the case of biofuels, affects the physical and agricultural biodiversity upon which many vital natural processes such as the cycle of carbon, nitrogen, water and soil fertility rely.[105]

6. Overcapacity of infrastructure: Although not only a Greek phenomenon, significant overcapacity of biodiesel production units is being reported. The root cause behind this asymmetry according to the majority of the biofuels' producers of the questionnaire is that the EU, beginning in 2003, incentivized the investment in the biofuel sector heavily having a very ambitious vision about the penetration of biofuels. Another substantial reason is the biodiesel blending mandate and the quota system of this policy, which had been offering a relatively secure income in the growing market of fuels (growing until 2009). It is noted that equation defining each beneficiary's possible allocation is a combination of numerous factors, including the production capacity of the unit.

Opportunities

1. Since biodiesel is currently the only available liquid biofuel in Greece, the further promotion of its penetration by the policy makers looks like an one-way road towards the accomplishment of national targets regarding the renewable energy in transport (10% substitution of energy for transportation by renewable energy sources and 20% cut in greenhouse gas emissions from 1990 levels). Higher blending mandates with diesel could lift off the market and optimize the operation of existing biodiesel plants. Even after the forthcoming 7% cap on crop based biofuels is applied, a Greek market of higher biodiesel blending rate (10 or 15%) and with the current supply structure (energy crops mainly) would be within the allowed limits. The consumption of diesel for transport in 2013 was 2,043.107 ktoe[106] (thousands tons of oil equivalent) or 40% of total energy consumption for transport, whereas the consumption of gasoline was 2,774.485 ktoe. To reach the 10% renewable target would mean to substitute approx. 480 ktoe with biofuels. Provided that only biodiesel is currently available, the 480 ktoe equal to 23% percent of diesel consumption. The 7% cap on crop based biofuels is actually the 70% of the 10% target, which results in 336 ktoe or 16.5% blending rate. Thus, without changing the current market structurally, but meeting other conditions such as new blending standards, feasibility approvals etc., the overall yearly biodiesel allocation could increase by at least 200%. Conclusively, more than doubling of the current blending rate – from 7% to 15%, seems feasible. Such policy would contribute very essentially to achieving the national target of renewables in transportation, augmenting greatly the utilization of installed infrastructure

[105] Paschalidou, A. et al, (2016), Energy crops for biofuel production or for food? - SWOT analysis (case study: Greece), Renewable Energy, Vol. 93, p. 642, Elsevier, Amsterdam, The Netherlands
[106] According to IEA (International Energy Agency). Data downloaded from http://www.iea.org/statistics/onlinedataservice/.

with many upsides for the economy (creation of jobs, support of rural areas, increase of tax income and so on).

2. As stated above, the import and production of bioethanol is totally a new ground for business. According to the biodiesel producers, a concrete legal and investment framework is of key importance to attract potential entrepreneurs to invest. Provided that the blending of bioethanol with gasoline is imposed as a mandate, similar to biodiesel and relative practices in the EU and globally, a large market would instantly emerge. Taking into account the 2013 gasoline consumption for transport in Greece which was 2,643[107] thousand tons or approximately 3,600 thousand cubic meters (the average density of gasoline is 0.735 ton per cubic meter at the temperature of 15 Celsius degrees) and a hypothetical blending mandate of ethanol with gasoline at 3.9% (as in Spain in 2013[108] – a country with resembling climatic conditions to Greece and member of EU), the required bioethanol would amount to 140 thousand cubic meters which is exactly the size of the Greek biodiesel market (140 thousand cubic meters in 2015).
3. Apart from the transportation sector which absorbs totally the liquid biofuels in Greece, there could be other appliances as well. As analyzed in §2.1.1, the aviation and marine sectors are potential new customers of biofuels with capacity to intake massive quantities of them. However this is unlikely at least for the short term or mid- term future, as no sign of moving into that direction in Greece has shown up until now. Other potential and more probable appliances, due to the fact that the legal framework is present (L.3468/2006), include the blending of biodiesel with heating gas oil for industrial and residential heating purposes and the usage of blended diesel for power generation. The heating gas oil market in Greece was approximately 4,000 thousand cubic meters and a 5% blend of biodiesel (i.e. 200,000 cubic meters of biodiesel) with heating gas oil is technically viable without any adjustment on installed heating infrastructure (burners). While, regarding power generation, the National Power Company consumes 480 thousand cubic meters to supply its diesel fuelled power plants. So, a blending rate of 5 - 7% would lead to another 30 to 33 thousand cubic meters new demand of biodiesel per year.[109]
4. Double counting which refers to the contribution of biofuels from non-food crops to the 10% renewables in transport target, offers opportunity for development. Biofuels from used cooking oil (UCO) and animal fats as well as advanced biofuels from lignocellulosic materials and innovative fuels created from these feedstocks that enable greater reductions in greenhouse gases

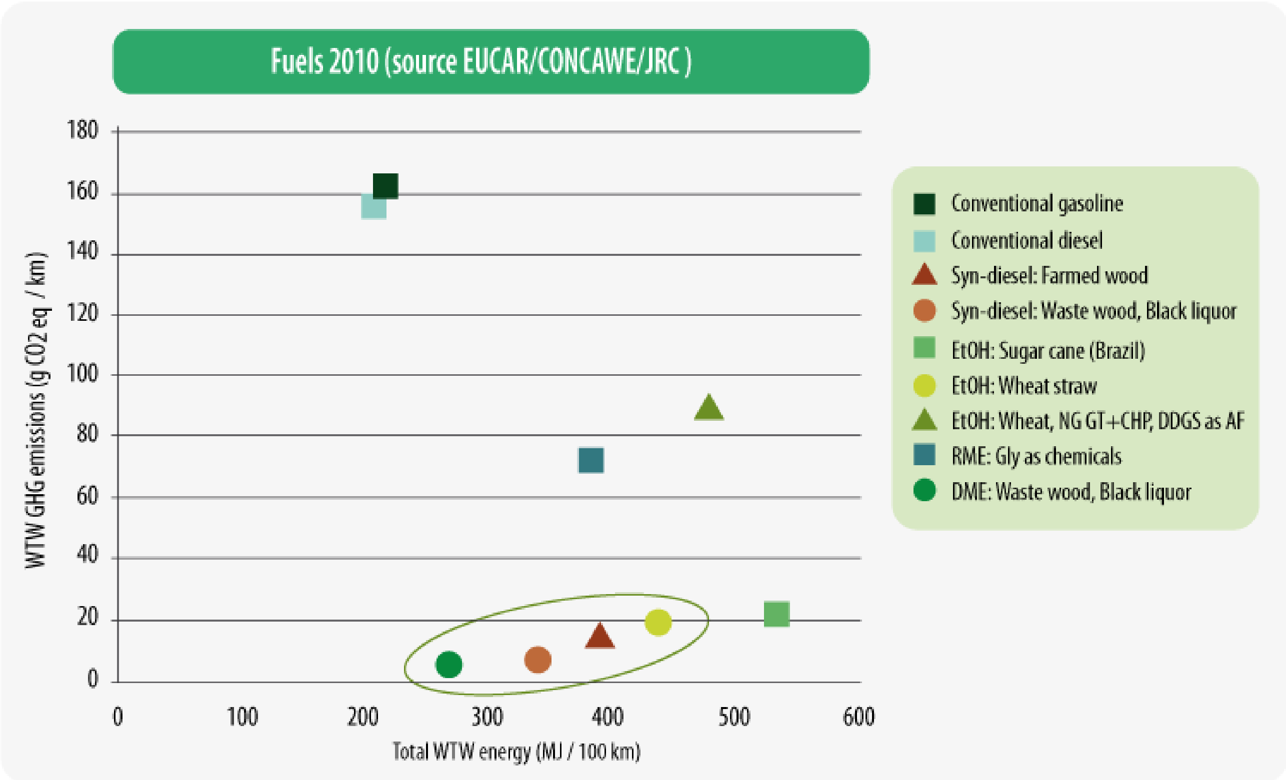
[107] According to IEA (International Energy Agency). Data downloaded from http://www.iea.org/statistics/onlinedataservice/.

[108] Guerrero, M., (2013), Spain's Bioethanol Standing Report, USDA Foreign Agricultural Service, p. 10, Madrid, Spain

[109] F.E.I.R. (2010), Renewable fuels in Greece: deficits and potential, Foundation for Economic & Industrial Research, p. 49 – 48, Athens, Greece

(GHGs), would count double in the 10% target provided that such a provision is adopted in the local legislation. The biofuel producers questioned have already included used cooking oil and animal fats in their feedstock portfolio, therefore the implementation of the double counting scheme in Greece would add value to the sector quickly and work in convergence with the applied strategy (in particular Elin Biofuels S.A. produces biodiesel exclusively from used cooking oil and animal fats[110]).

Figure 16. GHG emissions of conventional and innovative fuels from advanced biofuels.



Source: http://biofuelstp.eu/sustainability.html, GHG reduction and Sustainable Production of Biofuels, European Biofuels Technology Platform

5. Marginal lands which in general are of poor quality with regard to agricultural use could possibly be used for biomass production. This utilization is less likely to disrupt the ecosystem or generate increases in food and land prices, since marginal lands are not employed in production processes.[111]

Threats

1. Although the absence of bioethanol activity in Greece has been described as an opportunity for new business, it poses a threat at the same time. Given that the enhancement of the biofuel sector with bioethanol has been delayed for so

[110] http://elinbio.gr/activities#production-process
[111] Paschalidou, A. et al, (2016), Energy crops for biofuel production or for food? - SWOT analysis (case study: Greece), Renewable Energy, Vol. 93, p. 642, Elsevier, Amsterdam, The Netherlands

long, the achievement of national targets until the very close horizon of 2020 remains doubtful.[112]

2. While achieving the 2020 targets seems dubious, there has been no sign of updated national planning beyond 2020 until nowadays. The lack of such strategic plan will be deferring the potential development of the local biofuels' market, depriving it of competitiveness against markets of other countries more advanced in terms of organization and planning.
3. A stable legal and regulatory framework is fundamental for the advancing of any sector. Just in eight years, four major legal acts have been introduced, the one amending the other, accompanied by numerous ministerial decisions, technical standards and customs provisions. As argued by all the biofuel producers of our questionnaire, the frequently changing institutional framework is wounding the industry.
4. High relative costs limit the sustainability and question the viability of the industry. The sector study performed by the Foundation for Economic & Industrial Research highlights the presence of greater costs compared to other EU countries, throughout the supply chain, including the cost of feedstock, production, logistics, storage and handling. The relatively high cost of feedstock in Greece is considered to be the most material factor for the high price of the final product. Similarly to other crops, energy cultivations also suffer from the extended segmentation of land in small ownerships, which blocks the economies of scale.[113] If it were not for the biodiesel allocation program that regulates in total the produced and traded quantities and thus the prices, giving by far priority to domestic production (for instance in 2015, 93% domestic and 7% imports), there is a possibility that extensive low cost imports would have flooded the market. In addition, the fact that the Biofuel Producers pay for value added tax (VAT) with their purchases but do not collect VAT from their sales since they sell untaxed product, creates a significant working capital restraint, which is amplified due to the delays at the return of VAT from the Greek State.

[112] Mitkidis, G., (2015), MBA Dissertation: Feasibility of 2nd Generation Biofuels in Greece, p. 42, Hellenic Open University, Patras, Greece

[113] F.E.I.R. (2010), Renewable fuels in Greece: deficits and potential, Foundation for Economic & Industrial Research, p. 40 – 41, Athens, Greece

Chapter 3: Modeling Diesel and Biodiesel Demand

3.1 Literature and Review

The aim of this chapter is to provide an up-to-date empirical analysis of the demand for automotive fuels in Greece including the most recent historical data available, develop an econometric model so as to estimate their future demand and end up in assessing the potential demand for biofuels according to various possible policy scenarios on the thresholds of 2020, 2030 and even further.

As highlighted several times before, the only biofuel substituting automotive fuels currently in Greece is biodiesel. Therefore, our model will be designed to fulfill the specifications of diesel demand and naturally our target will be to estimate the demand for biodiesel in the end. Of course, the potential demand for gasoline and bioethanol could also be investigated likewise, creating opportunity for further elaboration on the matter.

Thus, the analysis and forecasting of diesel demand for road transport is a key milestone in our effort to assess the demand for biodiesel. Although it is a rather complicated topic, road energy demand has been studied by economists mainly globally and in a few cases locally for a long time. The pattern followed by the majority of the researchers includes the measurement of the impact of certain exogenous variables, such as gross domestic product, automotive fuel prices, vehicle fleet etc., the application of cointegration techniques in order to estimate the relevant elasticities (price, income).[114]

The work of Baltagi and Griffin[115] estimates gasoline demand for OECD countries. Dunkerley and Hoch[116] estimate similarly for developing countries. Garbacz[117] examines the gasoline, diesel and motor fuel demand in Taiwan. Bentzen[118] uses an error correction model in order to estimate short-run and long-run gasoline demand elasticities in Denmark. McRae[119] uses econometric models in order to capture the main determinants of gasoline demand in the Asian developed countries, while

[114] Polemis, M., (2006), Empirical assessment of the determinants of road energy demand in Greece, Energy Economics, Vol. 28, p. 386, Elsevier, Amsterdam, The Netherlands

[115] Baltagi, B. and Griffin, M., (1983), Gasoline demand in the OECD – an application of pooling and testing procedures, European Economic Review, Vol. 22, p. 117 – 137, Elsevier, Amsterdam, The Netherlands

[116] Dunkerley, J. and Hoch, I., (1987), Energy for transport in developing countries, Energy Journal, Vol. 8, No. 3, p. 57 – 72, International Association for Energy Economics, Ohio, USA

[117] Garbacz, C., (1989), Gasoline, diesel and motor-fuel demand in Taiwan. Energy Journal Vol. 10, No. 2, 153 – 163, International Association for Energy Economics, Ohio, USA

[118] Bentzen, J., (1994), An empirical analysis of gasoline demand in Denmark using cointegration techniques, Energy Economics Vol. 16, p. 139 – 143, Elsevier, Amsterdam, The Netherlands

[119] McRae, R., (1994), Gasoline demand in developing Asian countries, Energy Journal Vol. 15, No. 1, p. 143 – 155, International Association for Energy Economics, Ohio, USA

Ramanathan and Geetha[120] apply single equations functions to measure the impact of price and income in gasoline demand in India. Nicol[121] uses an empirical model to estimate the main determinants of gasoline demand in Canada and USA, employing a simultaneous system of equations and use cross-section data per household. Alves and Bueno[122] explore the gasoline demand in Brazil using an error-correction model. Polemis[123] investigates the main determinants of the road energy demand in Greece, estimating the income and price elasticities of gasoline and diesel demand in Greece during the period 1978 – 2003 using annual time series. He applies cointegration techniques to estimate road demand and to examine the issue of income and price sensitivity of both the short and long-run road demand for gasoline and diesel, respectively.

This paper aspires to contribute in the research of the field of road transport energy demand and be innovative due to the fact that:

1. Employing up-to-date data from 1978 until 2014, the results will also include the impact of the great economic recession Greece has been suffering since 2009.
2. The focus will be on the automotive diesel demand which has been studied much less compared to the gasoline demand worldwide, capturing as well the recent lifting (November, 2011) of the ban on the movement of vehicles with diesel engines in Attica and Thessaloniki[124], which is transforming the car market.
3. For the first time, the biofuel future demand will be linked on one hand with results derived from empirical analysis and econometric model and on the other hand with possible policy scenarios concerning the biodiesel blending mandates.

Following the specifications of Bentzen (1994), Samimi (1995), Eltony and Al-Mutairi (1995), Ramanathan (1999), Alves and Bueno (2003) and Polemis (2006) one log-linear form using per capita income (GDP), real energy price of diesel and per capita diesel vehicle fleet as independent variables is used in the empirical analysis. Therefore, the following specifications for the long-run road demand for diesel are employed:

---

[120] Ramanathan, R. and Geetha, S., (1998), Gasoline consumption in India: an econometric analysis, Proceedings of the First Asia Pacific Conference on Transportation and the Environment, National University of Singapore, Singapore p. 312 – 319

[121] Nicol, C.J., (2003), Elasticities of demand for gasoline in Canada and the United States, Energy Economics Vol. 25, p. 201 – 214, Elsevier, Amsterdam, The Netherlands

[122] Alves, D. and Bueno, R., (2003), Short-run, long-run and cross elasticities of gasoline demand in Brazil, Energy Economics, Vol. 25, p. 191 – 199, Elsevier, Amsterdam, The Netherlands

[123] Polemis, M., (2006), Empirical assessment of the determinants of road energy demand in Greece, Energy Economics, Vol. 28, p. 385 - 403, Elsevier, Amsterdam, The Netherlands

[124] L. 4030/2011, Article 50

$$\ln(DIESELCONSUMPTION_t) = b_0 + \overset{+}{b_1\ln(GDP_t)} + \overset{-}{b_2\ln(DIESELPRICE_t)} + \overset{+}{b_3\ln(DIESELFLEET_t)} + u_t$$

where $DIESELCONSUMPTION_t$ is the dependent variable and stands for the per capita diesel consumption for road transport at time t, GDP_t stands for the gross domestic product per capita income at time t, $DIESELPRICE_t$ stands for the real price of diesel (final one - including taxation) at time t, $DIESELFLEET_t$ stands for the per capita diesel-engined fleet at time t, and finally ut stands for the disturbance term at time t. The positive and negative signs on top of the independent variables indicate the respective relationship with the dependent variable they are expected to have. The effects of other fuels, possibly substitutes, such as the price of gasoline and autogas (autogas refers to liquefied petroleum gas for vehicles) have been studied as well in order to be included as independent variables in the model. However, not only was their impact statistically insignificant but also created severe distortion to the function of the model. Although it is difficult to economically interpret this effect, we believe that the main reason behind it is that in Greece, there has been no or very low substitutability between diesel and gasoline or diesel and autogas. Until 2011, the great majority of diesel vehicles have been heavy duty trucks, light duty trucks, buses, taxis, agricultural and other special vehicles. These vehicle types run only on diesel. Perhaps taxi drivers could turn to gasoline, but for reasons that are explicitly analyzed in the following section (§3.2.1), it is by far more economical to run on diesel than gasoline. Thus, all taxi cars are diesel fueled. Few light duty trucks could operate with gasoline, but yet again, limited outside the Athens and Thessaloniki cities' limits until 2011. Therefore, their number would be insubstantial. Furthermore, there is no economically feasible solution for the transformation of diesel engine to gasoline or to autogas, as in the case of gasoline engines. Such technical transformations of gasoline fueled engines to autogas fueled have been made very economical in the past few years (costing on average approx. 1,000 € per vehicle), resulting in a growing market for lpg in Greece. Summarizing, until 2011, the majority of commercial/duty vehicles were diesel fueled, whereas the majority of passenger cars were gasoline fueled (in 2010, approx. 95% of total fleet were registered as gasoline and 5% as diesel).[125] From 2011 and on, the diesel car market is reborn and substitutability between diesel and gasoline is commencing. Diesel cars increased their market share by 2014 to 8%. Nevertheless, there are only 4 years out of our sample's 37 in total of clear substitutability, which are relatively very few to be capable of creating statistical significant effect to our model.

The data used in the empirical estimation are national time series data expressed in logarithms (ln) covering the period 1978 – 2014. The 2015 records were not included for they had not been yet finalized at the time of the analysis. The per capita consumption for diesel oil (DIESELCONSUMPTION) is measured in kilograms per

[125] Association of Motor Vehicle Importers Representatives, http://www.seaa.gr/en

capita. These data were made available from the International Energy Agency.[126] The per capita GDP is expressed in constant 2009 prices, is measured in euros per capita and is obtained from the Eurostat Database[127]. Energy prices for diesel (DIESELPRICE) are taken from Energy Prices and Taxes (IEA)[128], include all taxation (VAT, Excise Duties, Other Fees), are expressed in euros per liter and have been deflated by the consumer price index (2009=100). Finally, the variable that measures the per capita fleet (DIESELFLEET) of diesel engine vehicles (buses, heavy commercial vehicles and passenger cars from 2011 and on) is obtained from the database of the Association of Motor Vehicle Importers Representatives (AMVIR)[129] and is expressed in vehicles per capita.

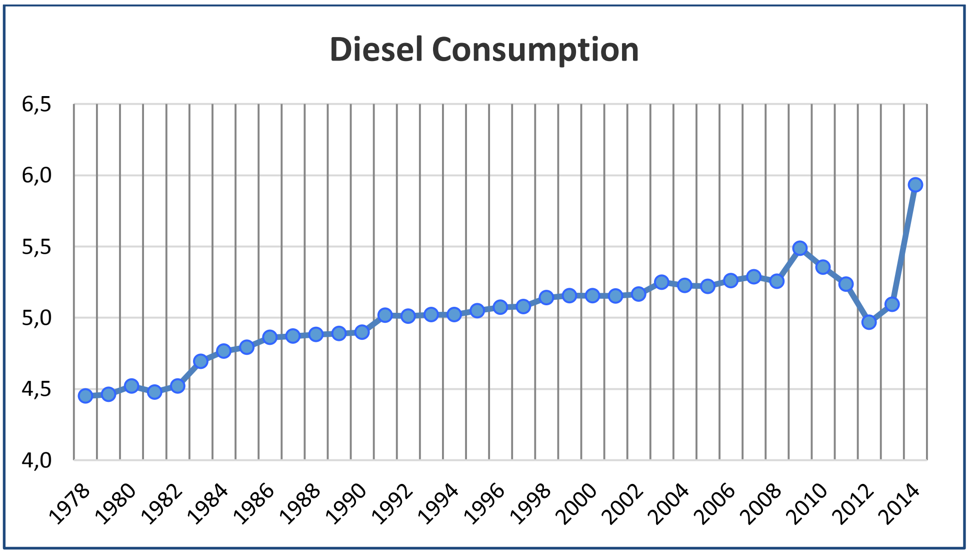
[126] International Energy Agency, http://www.iea.org/bookshop/661-Energy_Balances_of_OECD_Countries
[127] Eurostat, http://ec.europa.eu/eurostat/data/database
[128] International Energy Agency, http://www.iea.org/statistics/onlinedataservice/
[129] Association of Motor Vehicle Importers Representatives, http://www.seaa.gr/en

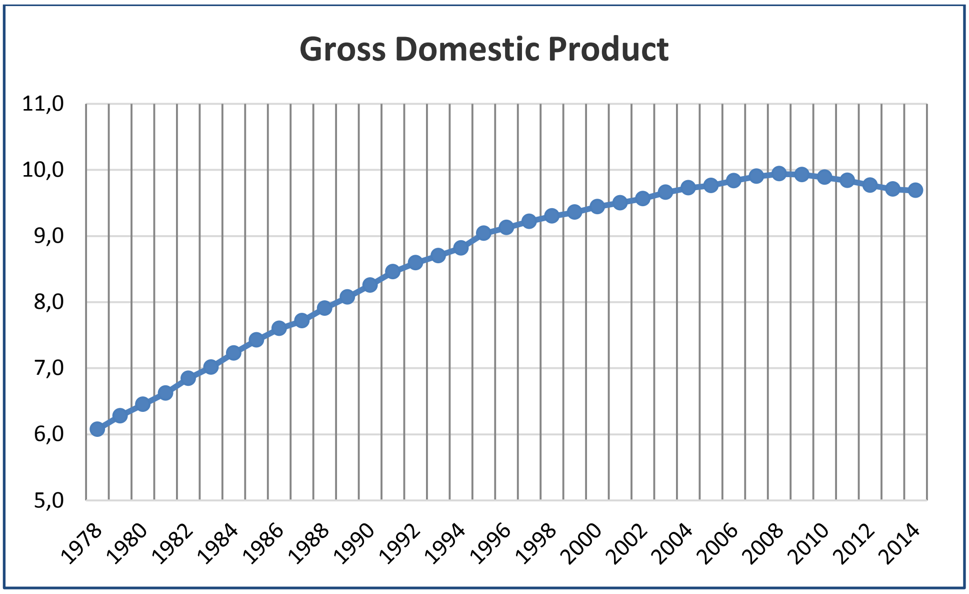
3.2 Empirical Analysis

3.2.1 Stationarity Test

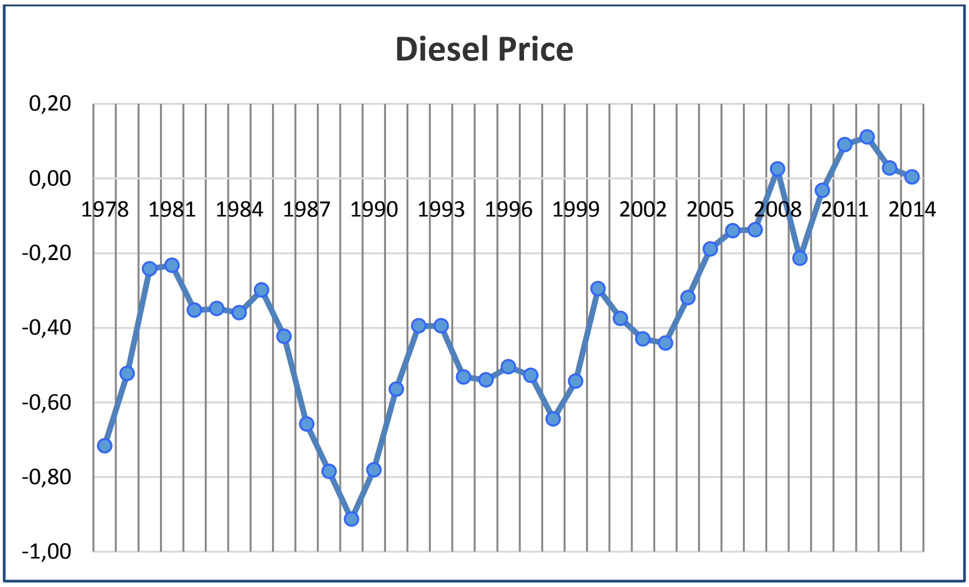
The graphical illustrations of the variables support our a priori expectations about absence of stationarity on levels. Time series are frequently not well characterized as being stationary processes and so the first step is to examine the stationarity of the variables. In other words, we have to check for the presence of unit roots. If variables are non-stationary I(1) processes, then there may exist a linear combination which may well be stationary I(0) processes. If this is the case then the variables are cointegrated.[130]

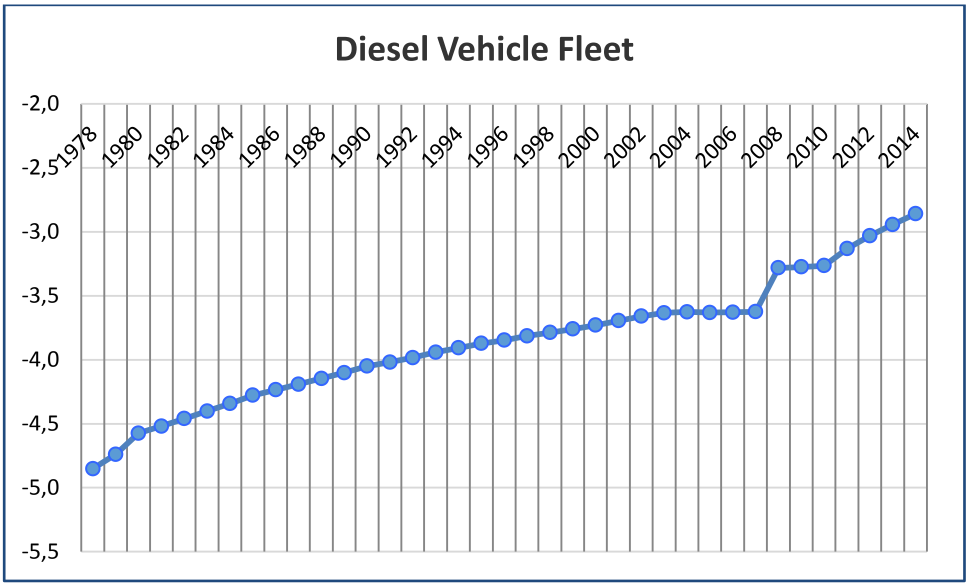
Figure 17. Graphs of model variables (Eviews Analysis)





[130] Rapanos, V., Polemis, M., (2005), Energy demand and environmental taxes: the case of Greece, Energy Policy, Vol. 33, p. 1781 - 1788, Elsevier, Amsterdam, The Netherlands





Source: Author's Econometric Analysis

As the economy grew (GDP graph) from 1978 to 2008, so did the fleet of diesel vehicles and naturally the diesel oil consumption. It is worth noticing though, that despite the turnaround of the economy which can be at first merely observed in 2009, becoming clearer afterwards, the variables of diesel fleet and consumption drive a different course. This seemingly controversial trend is due to the fact that as we mentioned before, the diesel cars' market was reborn in 2011, following the end of the prohibition on the circulation of diesel cars in the areas of Attica and Thessaloniki, which host the majority of passenger cars throughout the country. Based on 2007 records[131], 57% of total passenger cars in Greece were registered in

[131] Association of Motor Vehicle Importers Representatives, http://www.seaa.gr/en

Attica and Thessaloniki. However, it is quite common for Greeks to register their cars in other prefectures (i.e. in their home towns) even if they reside in Athens/Thessaloniki. Thus, the ratio of passenger cars actually moving in these cities is expected to be even higher. The high attractiveness of modern diesel fueled engines versus gasoline fueled in Greece derives from the blending of the following factors which together offer lower cost per kilometer:

- Diesel engines are in general more efficient in terms of fuel consumption. Their superiority in efficiency cannot be quantified, as it varies greatly depending on type of car, company, model etc. In the past, diesel engines were considered not capable of meeting the gasoline engines performance, but this perception is now obsolete, as almost all car companies have invested greatly to upgrade their diesel technology.
- The taxation on diesel is much lower. The excise duties for all kinds of gasoline are nowadays 0.67 €/liter while for diesel 0.33 €/liter. The VAT is the same (23%), however it is imposed on the price of the fuel including the excise duties, resulting in greater VAT effect. The costs of the basic fuels, diesel oil or gasoline, are fluctuating as their commodities are fully commercialized and depend on regional and global supply and demand variations. Usually the price of basic diesel is slightly lower compared to basic gasoline. In 2015 on average, the cost of the basic diesel oil for Greece (Ultra Low Sulfur Diesel with Sulfur content 10 parts per million) was 509 USD/Metric Ton. During the same period, the basic gasoline for Greece (Gasoline of 95 octanes EN 228) cost 570 USD/Metric Ton. Thus, the basic diesel oil was approximately 10% cheaper than gasoline.[132] Summarizing and taking into account the total of the cost elements, from 2005 - when biodiesel was first introduced in Greece and blended with diesel oil - until 2014, the total price of gasoline was 32% higher than the one of diesel oil.[133]

In order to proceed further into the stationarity testing of the above time series, we have to check for the presence of unit roots. The graphical illustrations provide evidence that our variables are probably non-stationary I(1). In order to examine the order of integration, we apply a series of diagnostic tests both in levels and first differences of these variables (Augmented Dickey-Fuller, Phillips-Perron, KPSS and Ng-Perron tests).

The results of the above tests are presented in below table:

[132] Data recovered from Platts price report http://www.platts.com/products/european-marketscan
[133] International Energy Agency, http://www.iea.org/bookshop/661-Energy_Balances_of_OECD_Countries

Table 8. Tests for unit roots.

Variables	Augmented Dickey-Fuller			Phillips-Perron		KPSS		Ng-Perron				*Orders of integration*
	Lags	**τt**	**τμ**	**τt**	**τμ**	**nt**	**nμ**	**MZa**	**MZt**	**MSB**	**MPT**	
Levels												
GDP	1	-1.50 (0.811)	-1.18 (0.671)	-0.95 (0.939)	-1.17 (0.677)	0.11 [4]	0.58** [5]	-9.60 [1]	-2.01 [1]	0.21 [1]	10.23 [1]	I(1)
DIESELPRICE	0	-2.59 (0.285)	-1.56 (0.490)	-2.26 (0.446)	-1.78 (0.385)	0.16** [4]	0.51** [4]	-6.82 [0]	-1.83 [0]	0.27 [0]	13.37 [0]	I(1)
DIESELFLEET	0	-1.93 (0.620)	-0.33 (0.911)	-2.12 (0.519)	-0.31 (0.913)	0.11*** [4]	0.74** [5]	-4.85 [0]	-1.43 [0]	0.29 [0]	18.06 [0]	I(1)
DIESELCONSUMPTION	5	-2.28 (0.435)	-2.99 (0.466)	-2.09 (0.536)	-2.21 (0.208)	0.20** [3]	0.66** [5]	0.58 [3]	0.48 [3]	0.81 [3]	44.48 [3]	I(1)
First Differences												
Δ(GDP)	0	-3.51* (0.054)	-3.49** (0.014)	-3.48* (0.058)	-3.47** (0.015)	-	0,20 [4]	-14.04** [0]	-2.65** [0]	0.19** [0]	6.50** [0]	I(0)
Δ(DIESELPRICE)	0	-4.75*** (0.003)	-4.80*** (0.000)	-6.23*** (0.000)	-5.15*** (0.000)	0.11 [8]	0.11 [8]	-15.9* [0]	-2.82* [0]	0.18* [0]	5.73* [0]	I(0)
Δ(DIESELFLEET)	0	-5.93*** (0.620)	-6.01*** (0.000)	-5.95*** (0.000)	-6.03*** (0.000)	0.19** [2]	0.19 [2]	-17.30** [0]	-2.93** [0]	0.17** [0]	5.32** [0]	I(0)
Δ(DIESELCONSUMPTION)	3	-4.03*** (0.017)	-0.53*** (0.000)	-5.82*** (0.000)	-5.20*** (0.000)	0.31 [25]	0.50* [35]	-201.95*** [2]	-9.96*** [2]	0.05*** [2]	0.23*** [2]	I(0)

Notes: The relevant tests are derived from the OLS estimation of the following autoregression for the variable involved: $\Delta Y_t = \delta + \beta Y_{t-1} + \gamma t + \Sigma \alpha_i \Delta Y_{t-i} + u_t$ **τμ** is the t-statistic for testing the significance of **β** when a time trend is not included in the equation and **τt** is the t-statistic for testing the significance of **β** when a time trend is included in the equation. The calculated statistics are those reported in Dickey and Fuller (1981). The critical value at 5 and 1% for N=50 are given in Dickey and Fuller (1981). The optimal lag length structure is determined by minimizing the Schwarz Info Criterion (SIC). The critical values for the Phillips-Perron unit root tests are obtained from Dickey and Fuller (1981). The numbers in parenthesis denote the MacKinnon (1996) one-sided p-values. The numbers in brackets [] denote the lags using the Newey-West bandwidth. **nμ** and **nt** are the KPSS statistics for testing the null hypothesis that the series are I(0) when the residuals are computed from a regression equation with only an intercept and intercept and time trend respectively. The critical values are given in Kwiatkowski et al. (1992). The Ng-Perron statistic tests the null hypothesis that the series are I(1) including an intercept and a deterministic trend.

******* denotes the significance in 1% level. ****** denotes the significance in 5% level. ***** denotes the significance in 10% level.

<u>**Source**</u>: Author's Econometric Analysis

The conducted tests show that the null hypothesis of a unit root (no stationarity) cannot be rejected in levels for all the variables. Looking into the results of KPSS test and more specifically at the nt statistic of KPSS (test of intercept and time), we observe that the variable of GDP (gross domestic product per capita) appears to be stationary at levels. However, this particular observation of KPSS is not in line with the alternate test of KPSS, i.e. the nμ statistic (test of intercept) which indicates absence of stationarity and is in line both with the graphical illustration and the full tests of the Augmented Dickey-Fuller, Phillips-Perron, KPSS and Ng-Perron methods. Thus, we adhere to our finding of absence of stationarity at levels.

Following the examination of stationarity at levels, we apply the tests at first differences. The results of each variable test support that the stationarity hypothesis cannot be rejected. More specifically, the stationarity hypothesis regarding the variables of GDP, DIESELPRICE and DIESELCONSUMPTION cannot be rejected at 10% level of significance, whereas regarding the DIESELFLEET, it cannot be rejected at 5% level of significance. Only one of the KPSS tests at DIESELFLEET, the trend and intercept one and at DIESELCOSUMPTION, the intercept one, indicate the absence of stationarity. Nevertheless, their alternate KPSS tests agree with all the other tests and graphs, resulting in strong support for the stationarity at first differences.

3.2.2 Cointegration Analysis

We continue our empirical analysis with the elaboration of cointegration techniques in our model in order to examine whether there is a long-run (structural) co-movement of the variables. Since non stationary time series result to spurious regressions and hence do not allow statistical interpretation of the estimations, we ought to apply cointregration techniques, in our case the Johansen methodology of maximum likelihood.[134] We bring to test two alternative statistics, first the maximum eigenvalues and secondly the trace statistic, in comparison with the Osterwald-Lenum critical values.[135]

The results of the cointegration tests are shown below in table 9. The estimation of trace statistic provides solid evidence that one vector of cointegration between the model's variables exists. More specifically, we carry out tests on four different specifications: 1) No intercept and no deterministic trend, 2) Intercept and no deterministic trend, 3) Intercept no linear deterministic trend, 4) Intercept and linear deterministic trend 5) Intercept and quadratic deterministic trend.

[134] Hjalmarsson, E. and Österholm, Pär, (2007), Testing for Cointegration Using the Johansen Methodology when Variables are Near-Integrated, IMF Working Paper, International Monetary Fund, Washington D.C., USA

[135] Osterwald-Lenum, M., (1992), A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics, Oxford Bulletin of Economics and Statistics, vol. 54, p. 461 – 472, Oxford, UK

Table 9. Johansen's maximum likelihood method test for cointegration relationship.

Null Hypothesis Ho	Alternative Hypothesis	Eigenvalue	Critical Values	
			95%	99%
Intercept and linear deterministic trend				
Trace statistic				
r=0	r=1	70.72***	62.99	70.05
r≤1	r=2	42.03	42.44	48.45
Maximum eigenvalues				
r=0	r=1	28.69	31.46	36.65

Source: Author's Econometric Analysis

r denotes the number of cointegration vectors

*** denotes significance at 1% level.

The trace statistic tests result in the existence of one cointegration vector at 1% statistical significance level for specification 4 (as per Table 9) which is considered appropriate and at least two cointegration vectors for the other specifications.

Summarizing the results of the cointegration analysis, it becomes clear that the null hypothesis (no cointegration) is rejected at 1% level. In other words, one cointegration vector exists at 1% statistical significance level.

3.2.3 Long Run Regression Analysis

Having defined that our series are all stationary at their first differences and cointegrated as well, our next step is to assess the long run elasticities of the model. We follow the two-step Engle and Granger methodology by estimating an error correction model (ECM) through the Ordinary Least Squares (OLS) approach.[136] The main reason for using this approach instead of using a vector autoregression model (VAR) is that the latter is more sensitive to the number of lags that can be used.[137]

The OLS resulting estimates of our model are as follows:

DIESELCONSUMPTION = 0.60 GDP – 0.34 DIESELPRICE + 0.39 DIESELFLEET + U

[136] Engle, R. and Granger, C., (1987), Cointegration and error correction: representation, estimation and testing, Econometrica, Vol. 55, p. 251 – 276, New York, USA

[137] Polemis, M., and Dagoumas, A., (2013), The electricity consumption and economic growth nexus: Evidence from Greece, Energy Policy, Vol. 62, p. 798 - 808, Elsevier, Amsterdam, The Netherlands

Table 10. Long run regression

Variables	DIESELCONSUMPTION			
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C	0.62	1.19	0.52	0.606
GDP	0.60***	0.11	5.49	0.000
DIESELPRICE	-0.34***	0.08	-4.33	0.000
DIESELFLEET	0.39***	0.05	7.46	0.000
Diagnostics				
Adjusted R-squared	0.88			
Durbin-Watson stat	0.91			
LM Test	2.87			
	[0.110]			
White test	2.55			
	[0.150]			
J. Bera	6.74			
	[0.034]			
ARCH test	2.77			
	[0.105]			
Chow-test	5.77 11.32 5.27			
Breakpoints 1992, 2003, 2011	[0.002] [0.000] [0.000]			

Numbers inside brackets denote the *p* values.

***denotes significance at 1% level.

Source: Author's Econometric Analysis

Our first observation concerns the statistical significance of the independent variables. All of them are found to be significant at 1% level, except for the constant term (C), which is not statistically significant, not affecting however the quality of the model. The fact that the total of the variables' coefficients are statistically significant and at the same level, which also happens to be the highest (1%), supports the acceptance of the model so far. With reference to the diagnostics carried out for the long run regression, we have performed tests for the existence of autocorrelation and heteroskedasticity through Durbin Watson, LM, White and Arch tests, the results of which reject their existence (of autocorrelation and heteroskedasticity). Moreover, we applied to our sample data the Jarque-Bera test and found that it matches a normal distribution. Finally, the Chow Breakpoint tests for years 1992, 2003, 2011 – all of them considered as milestones for the local oil products' market, since the deregulation of the market first began in 1992[138], was completed in 2002[139] and the ban on diesel was lifted in 2011 – show that there have been structural breaks in the

[138] L. 1571/1985

[139] L. 3054/2002

diesel demand as expected. Regarding the coefficients, they do have the anticipated signs as described in §3.1. The income effect (GDP) is positive with relevant long-run elasticity below unity (0.60). The diesel price has a negative effect (-0.34), while the diesel fleet has positive (0.39). Both of them have almost the same magnitude (0.34 vs 0.39) with relative long-run elasticities below unity. 1% variation of GDP will lead to 0.6% variation of diesel demand, whereas 1% variation of the diesel price or fleet will lead to 0.3% variation of diesel demand (almost half compared to the GDP effect). Thus, we come to conclude that the diesel demand appears to be inelastic to variations of all its determining factors. The above results are in line and close to those reported in other countries, such as M. Bakhat et al (2013)[140] report for Spain (being of significant value as we believe since this report was conducted very recently in a country whose economy has been under recession and international financial supervision somehow related to Greece), F. Dunkerlay et al (2014)[141] report for UK and T. Sterner (2006)[142] reports for the OECD countries in his comprehensive research.

3.2.4 Short Run Regression Analysis

Following the long-run regression analysis, we carry on with assessing our model's responses (elasticities) in the short run, maintaining of course the error correction model approach the results of which are accumulated in table 11 below. Each coefficient of the variables denotes the short-run elasticity. All the coefficients of the variables of the diesel demand are in alignment with the theory and are statistically significant, except for the fleet of diesel vehicles which is not (in the short-run). Short-run income elasticity is below unity and is estimated to be 0.59, implying that a 1% increase of per capita GDP will increase diesel demand at a much lower rate (0.59%). The short run elasticity with respect to own price is estimated to be less than unity as well (0.23) implying low level response of diesel demand to its own price fluctuations which reveals the difficulty of consumers to substitute diesel with other energy products (gasoline, lpg, natural gas, hydrogen, fuel cells, etc.). The short run elasticities of both statistical significant variables are lower (at least slightly lower at the case of GDP) than the long run ones, satisfying the LeChatelier principle[143]. The error correction term $(ECT)_{t-1}$ is strongly significant (t statistic -3,73 and p value 0,0008) with an adjustment coefficient of -0.52, implying that, in the case we are off the long-run demand curve, diesel consumption adjusts towards its long-run level with about 52% of this adjustment taking place within the first year. The

[140] Bakhat, M. et al, (2013), Economic Crisis and Elasticities of Car Fuels: Evidence for Spain, Economics of Energy, ISSN 2172 / 8437, Vigo, Spain
[141] Dunkerley, F.et al, (2014), Road traffic demand elasticities, A rapid evidence assessment, Rand Europe, Cambridge, UK
[142] Sterner, T., (2006), Survey of Transport Fuel Demand Elasticities, The Swedish Environmental Protection Agency, Stockholm, Sweden
[143] Milgrom, P. and Roberts, J., (1996), The LeChatellier Principle, The American Economic Review, Vol. 86, No. 1

diesel dynamic demand function appears to be well behaved to the diagnostic tests including the adjusted R2 (35%), the serial correlation (LM test), the autoregressive conditional heteroskedasticity test (ARCH test) and the white for heteroskedasticity test. In other words, the estimated statistics support the structural stability of the estimated regression (diesel demand) for the examined period used in the empirical analysis.

Table 11. Short run regression

	D(DIESELCONSUMPTION)			
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(GDP)	0.59**	0.28	2.12	0.042
D(DIESELPRICE)	-0.23**	0.10	-2.33	0.026
D(DIESELFLEET)	-0.06	0.21	-0.27	0.786
ECM_RESID(-1)	-0.52***	0.14	-3.73	0.001
Diagnostics				
Adjusted R-squared	0.35			
Durbin-Watson stat	1.47			
LM Test	2.3			
	[0.119]			
White test	1.36			
	[0.256]			
J. Bera	9.98			
	[0.007]			
ARCH test	0.54			
	[0.468]			

Numbers inside brackets denote the *p* values.

** denotes significance at 5% level.

*** denotes significance at 1% level.

Source: Author's Econometric Analysis

3.3 Forecasting

After having calculated and tested our demand estimation model, we enter the area of forecasting, aiming to meet our end target, which comprises two consecutive steps: The first step to take would be to estimate the future demand of diesel oil. Secondly, we will proceed with the application of policy scenarios, regarding possible regulatory mandates of biodiesel blending, on the future diesel oil estimates. Thus, this process will enable us to formulate basic views of how the local biodiesel demand could potentially develop.

The energy forecast models are grouped under two major classes: The computable general equilibrium (CGE) models which are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors and the partial equilibrium models (PEM) which take into consideration only a part of the market, ceteris paribus, to attain equilibrium. In our case, we are referring to a partial equilibrium model since our study focuses on the demand of a single energy commodity.

3.3.1 Diesel Demand

Our forecasts will stretch from 2015 to 2030. It is not recommended to extend further in the future, as the longer the forecast is, the lesser its probability to occur.[144] We apply two forecast approaches:

1) The first one is rather short-term, extending from 2015 to 2020 and following the Box-Jenkins or ARIMA (autoregressive integrated moving average) methodology.[145] This method which is widely used for the analysis of time series, conducts forecasts for a time series Y_t based on its past values only, without any other structural information. For example, no information regarding which determinant variables have an impact on time series Y_t is required.[146] Since our series (DIESELCONSUMPTION) is not stationary on levels, we take the first differences and formulate a new series as follows:

$$D(DIESELCONSUMPTION)_t = DIESELCONSUMPTION_t - DIESELCONSUMPTION_{t-1}$$

Then we apply the ARIMA (1, 1, 1) model on the new series, which has below form:

$$D(DIESELCONSUMPTION)_t = b_o + b_1 D(DIESELCONSUMPTION_{t-1}) + e_t + a_1 e_{t-1}$$

Whereas b_1 is the autoregressive coefficient, a_1 is the moving average coefficient and e_t are the error terms (generally assumed to be independent, identically distributed variables sampled from a normal distribution with zero mean).

In general, the ARIMA models are considered to be appropriate for short-term predictions and this is the main reason for applying such technique for our up to 2020 forecast. The credibility of ARIMA models is evaluated with the calculation of the statistic RMSE (Root mean squared error).

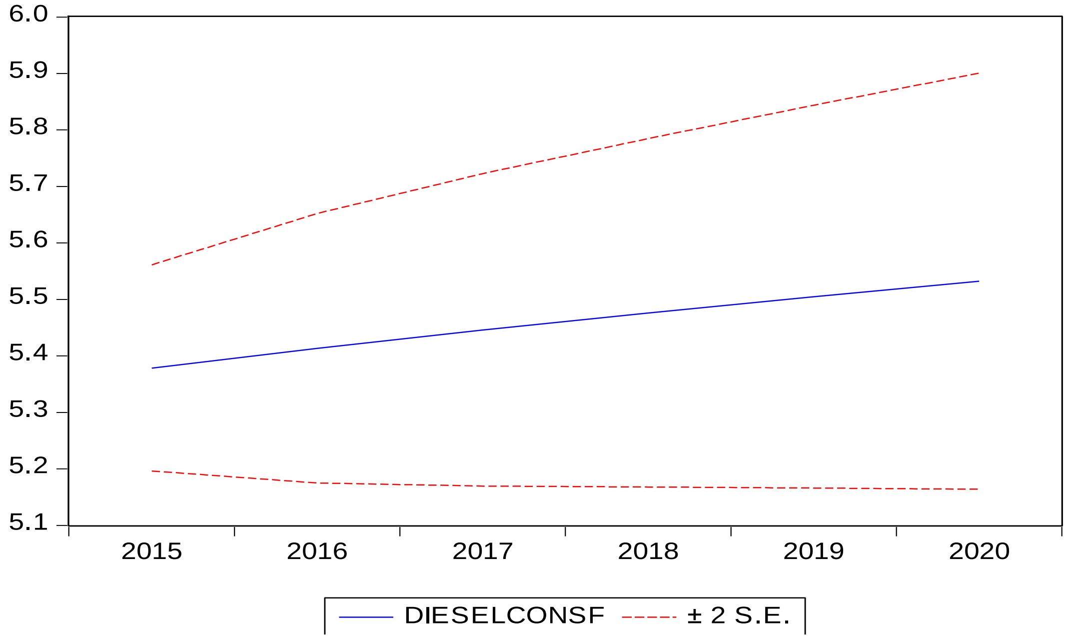
[144] Chatfield, C., (2001), Time-Series Forecasting, p. 7, Chapman & Hall/CRC, Florida, USA

[145] In time series analysis, the Box–Jenkins[1] method, named after the statisticians George Box and Gwilym Jenkins, applies autoregressive moving average ARMA or ARIMA models to find the best fit of a time-series model to past values of a time series.

[146] Tsionas, E., (2009), Statistical Packages and their Economic Applications, Excel, SPSS, EViews and Gauss in Economics, Statistics and Econometrics, p. 229 – 230, Athens University of Economics and Business, Athens, Greece

The results of this method are shown below:

Figure 18. Short-term forecast of diesel oil demand (ARIMA model).



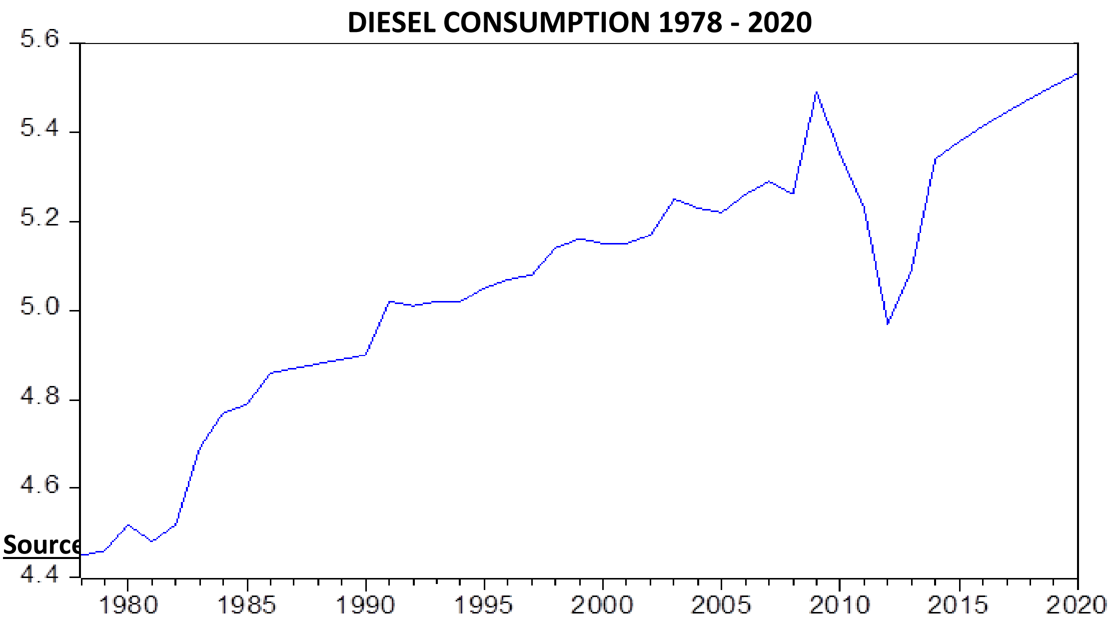
Notes:

On the verticals axis is the forecasted diesel consumption per capita in Ln values.

The dotted curves (red) represent forecasts with ± 2 standard errors.

Source: Author's Econometric Analysis

Figure 19. Diesel oil demand curve from 1978 to 2014 (historic values) and short-term forecast until 2020 (ARIMA model).



Source: Author's Econometric Analysis

Table 12. Diagnostics of ARIMA method.

ARIMA DIAGNOSTICS	
Forecast	DIESELCONSF
Actual	DIESELCONSUMPTION
Forecast sample	1978 - 2020
Adjusted sample	1980 - 2020
Included observations	35
Root Mean Squared Error	0,189537
Mean Absolute Error	0,175647
Mean Abs. Percent Error	3,470638
Theil Inequality Coefficient	0,019085
Bias Proportion	0,61233
Variance Proportion	0,000355
Covariance Proportion	0,387315

Source: Author's Econometric Analysis

As mentioned before, our dependent variable – the diesel consumption[147] – is the natural logarithm (Ln) of the diesel consumption measured in thousand tons per capita (divided by 1,000,000 in order to limit the digits of the numbers). So, we continue with the conversion of the forecasted logarithms into absolute numbers aiming to estimate the future demand of diesel oil in its basic unit of measure globally, i.e. thousand tons or kT.

Table 13. Forecast of Diesel Demand in thousand tons & annual change until 2020.

Year	Ln of Diesel Demand per Capita	Diesel Demand in kT	Diesel Demand VS Last Year
2014	5.34	2,317	
2015	5.38	2,410	4%
2016	5.41	2,482	3%
2017	5.45	2,559	3%
2018	5.48	2,630	3%
2019	5.50	2,702	3%
2020	5.53	2,769	2%

Source: Author's Econometric Analysis

[147] In the empirical part of this essay (Chapter 3), we study the demand of diesel (demand curve) through the interaction of the diesel quantity demanded (one particular point on the demand curve) with other variables. The quantity demanded is represented by the variable of diesel consumption. Thus the estimation of diesel quantities demanded will provide the future diesel demand curve.

2) The second approach which is more long-term as it extends from 2015 to 2030 follows the methodology of simple linear models and is recommended to apply if the values of determinant variables/factors are known or can be predicted.[148] The linear model to be used will be the one we studied and tested in the section of the empirical analysis of the long run regression in specific i.e.:

DIESELCONSUMPTION = 0.60 GDP – 0.34 DIESELPRICE + 0.39 DIESELFLEET + U

The greatest and most crucial challenge of this approach is of course the prediction of the determinant variables. To this end, we have developed three scenarios: First of all, we focus on one Reference scenario (RS) which is the most probable and afterwards, in line with the basics of sensitivity analysis[149], we design two alternative scenarios of equal deviation from the reference scenario and in our opinion of similar likelihood, the Over Performance scenario (OPS) and the Under Performance scenario (UPS).

The predictions for the evolution of the GDP, Diesel price and Diesel fleet differ in all three scenarios. Their logic is going to be detailed further on. The only factor remaining unchanged throughout the scenarios, affecting indirectly two out of three determinant variables and the dependable variable as well, is the population. We remind that GDP, Diesel Fleet and Diesel Consumption stand for variables per capita. We chose not to differentiate the population evolution projections, since on one hand no tangible studies with more than one probable to happen scenarios could be retrieved and on the other hand it is a far more complex issue that expands beyond economic implications and is associated greatly with social and cultural developments of high indeterminacy impact. The population evolution is derived from the Global Forecasting Model of University of Denver[150].

Regarding the evolution of the GDP, our Reference Scenario takes into consideration the most recent release of OECD[151]. From 2016 and on the economy is growing continuously, more intensively in the first 3 years (5% per year) and then gradually less intensively but significantly (3% for a period of ten years). The basic assumption of the two alternative scenarios is that the economy of Greece performs better and worse respectively compared to OECD forecasts. In order to achieve symmetry between the alternative scenarios, we applied equal – in absolute value – deviation rate from the reference one. Moreover, the deviation rate should be

[148] Tsionas, E., (2009), Statistical Packages and their Economic Applications, Excel, SPSS, EViews and Gauss in Economics, Statistics and Econometrics, p. 228 – 229, Athens University of Economics and Business, Athens, Greece

[149] Saltelli, A., (2002), Sensitivity analysis for importance assessment, Risk Analysis Journal, Vol. 22, Issue 3, John Wiley & Sons, New York, USA

[150] http://www.ifs.du.edu

[151] https://data.oecd.org/gdp/gdp-long-term-forecast.htm

significant so that the differentiations on the results would matter but not be chaotic, risking to provide unrealistic scenarios. Thus, in the OPS, the GDP evolution from 2015 to 2030 is accelerated by 50% each year, while in UPS, is decelerated by 50%. The GDP progress in all scenarios is the driver that designates the course of the other two determinant variables as well (Diesel Fleet and Diesel price partly).

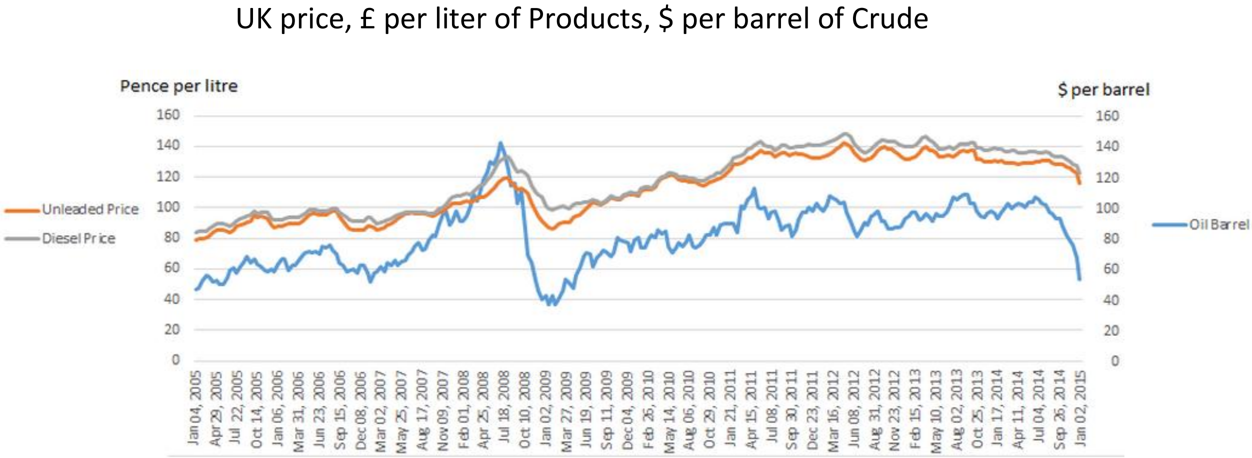
With reference to Diesel Fleet, in the RS, we assume that the speed of replacing gasoline fueled cars with diesel oil we have witnessed during the previous years of the recession and following the diesel ban lifting in 2011 will keep up. During 2011 – 2014, the average rate of diesel fleet growth has been 10% yearly which we maintain until 2030, while the average rate of gasoline fleet shrinkage has been 1.25%. We assume that this rate increases slightly to 2% until 2030, given the fact that the economy is expected to start growing again from 2016, so that people will even more decisively wish to replace their gasoline fueled vehicles. By 2030, the diesel vehicles' market share will have risen from 8% in 2014 to 35%, much closer to the current EU average of 53% (according to ACEA). The total fleet will count 8,273 million cars, 3% more than in 2014. In the OPS, we assume that the replacement rates will be even higher, with diesel fleet to be growing 15% for the first six years and then gradually balancing to 10% yearly, whereas the gasoline fleet will be shrinking 3% annually. In 2030, the diesel market share will hit 48% being very close to EU current average, while the total fleet will be 8% more than in 2014. Finally, in the UPS, the replacement rates will be approximately half compared to the RS, 5% increase of diesel fleet and 1% reduction of the gasoline fleet per year. Such course will to a diesel market share of 18% and total fleet approximately 4% less than it was in the beginning.

Predicting price variations can be a very complicated exercise with great uncertainties. Especially when dealing with fully commercialized commodities such as fuels, the prices of which are influenced in multiple manners and in various fields such as at physical markets, exchange houses, through over the counter transactions, due to supply and demand curves, speculation, arbitrage, political pressure, technology innovation, depletion of oil fields, competition from substitutes and so on. Although very few forecast schemes for the prices of petroleum products exist, for example by the Platts published daily under their Forward Curves assessment platform, they are rather short or medium term as they extend up to 36 months. Necessarily, we will have to simplify the process by adopting the following approach. Firstly, we decompose the end price (retail price) of diesel oil. It is comprised of taxation and commodity value. Then we decompose the taxation component which basically is VAT and Excise Duty.[152] Their cost contribution is known, e.g. the excise duty of diesel oil in 2014 is 330 € per 1,000 Liters and VAT is 23%. Removing the taxation from the end price leads us to the value of the commodity. So, our task now

[152] The VAT is imposed on the summation of commodity cost and Excise Duty.

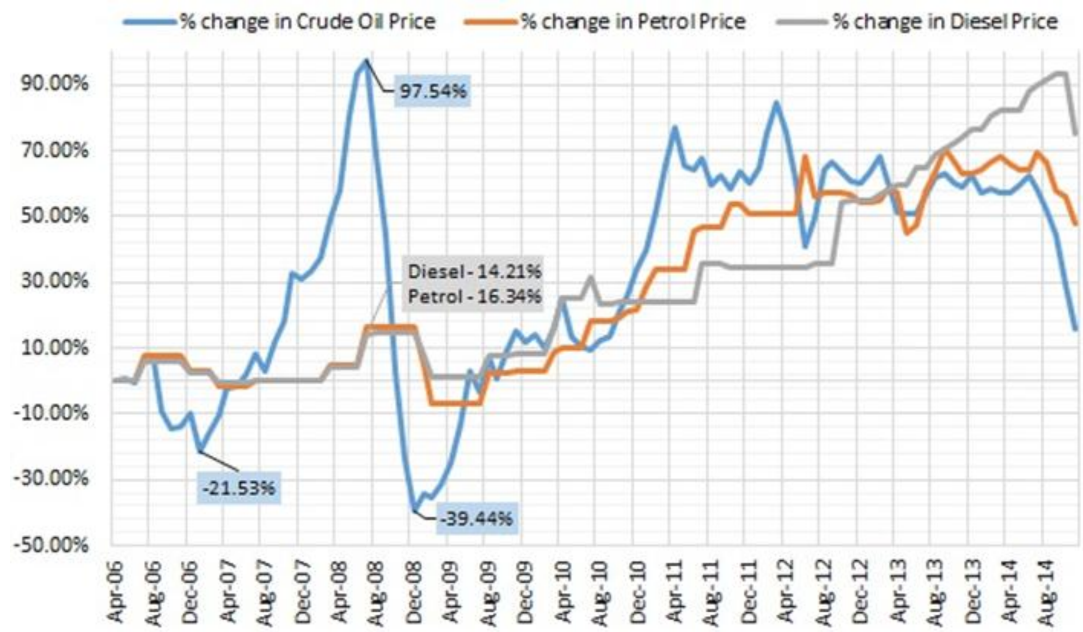
is about predicting the evolution of taxation and commodity. The commodity of interest is diesel oil, which is one of the many distillates of crude oil. Due to the fact that long run projections for petroleum products are not available, we make the assumption that the diesel oil evolution will follow the crude oil evolution in the long run. According to literature and historical data, such an assumption is realistic. The following charts clearly show that the long-term price fluctuations between crude and products are highly correlated.

Figure 20. Unleaded and Diesel Prices & Oil Price



Source: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_w.htm

Figure 21. Change in Prices – Crude Oil vs Petrol (Gasoline) vs Diesel



Source: http://capitalmind.in/

Therefore, we will parallel our predictions for the evolution of the commodity value of diesel with the latest forecast of World Bank for crude oil[153], applying the same to all three scenarios naturally, since the local economic developments are very much unlikely to influence the global prices of crude oil. After completing the curve for the commodity value of diesel, we enter the area of tax policy forecast. Given the fact that historically governments tend to raise the taxation when the economy is under performing while they tend to leave it as is in case of normal or better performance, we formulate the following assumptions. In the RS, the VAT of 23% in 2014 will increase to 24% in 2016 (as it is already decided) and remain at this level throughout the period. The average VAT in EU is currently 21.5%. The excise duty which is 330 € per 1,000 Liters in 2014, will increase to 410 € in 2017 (adopted legislation) and will gradually reach 438 € per 1,000 Liters by 2030, i.e. current average of EU. It is noted that the current excise duty of 330 € is the minimum allowed in accordance with the Energy Directive (Council Directive 2003/96/EC). In the OPS, the VAT shall increase to 24% in 2016 (adopted legislation) and gradually deescalate to 21.5% (EU average). The excise duty will rise to 410 € in 2017 (adopted legislation) and remain at this level. In the UPS, both VAT and excise duty will gradually increase to the highest in the EU as per current levels, i.e. the VAT will rise to 27% (as is currently in Hungary) and the excise duty will reach 623 € per 1,000 Liters (as is currently in Sweden).[154]

Finally, we perform the opposite process, meaning adding up the taxation elements to the commodity values, in order to compose the diesel oil end price per scenario. At this point, all our determinant variables in all the three scenarios have been calculated. We continue with feeding them in serially in our linear model (of the long-run regression) and produce the results for the evolution of diesel oil demand on each scenario. Then, similarly to the previous approach (ARIMA model) we reverse the natural logarithms of diesel consumption per capita into its basic unit of measure (thousand tons). These results are incorporated in the following graph and tables.

[153] http://www.worldbank.org/en/research/commodity-markets

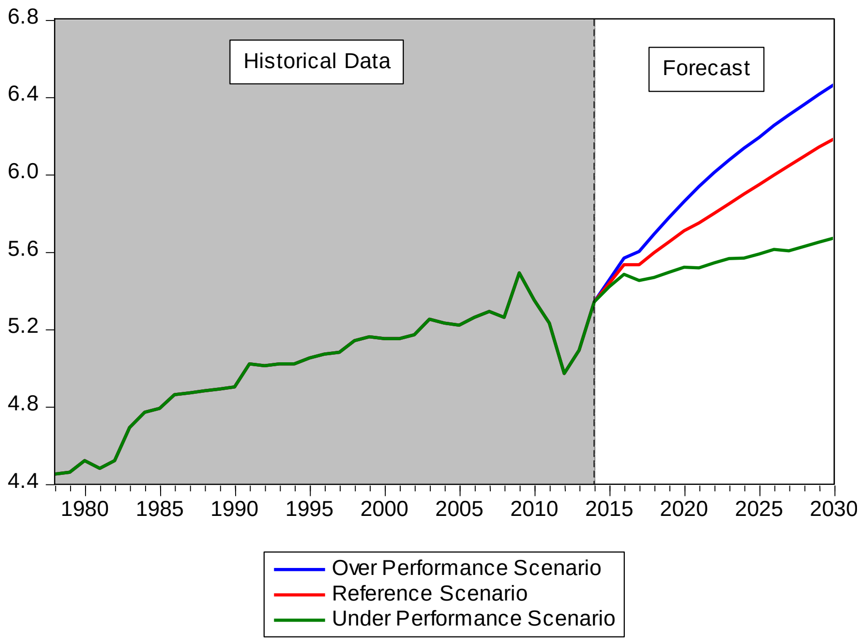
[154] Fuel excise duty and VAT data have been derived from EXCISE DUTY TABLES, European Commission (2016), http://ec.europa.eu/taxation_customs/index_en.htm

Table 14. Evolution of the determinant variables of diesel oil demand until 2030 on 3 alternative scenarios.

	Under Performance Scenario			Reference Scenario			Over Performance Scenario		
YEAR	GDP	DIESEL FLEET	DIESEL PRICE	GDP	DIESEL FLEET	DIESEL PRICE	GDP	DIESEL FLEET	DIESEL PRICE
2014	-1%	9%	-4%	-1%	9%	-4%	-1%	9%	-4%
2015	0%	5%	-33%	0%	10%	-33%	0%	15%	-33%
2016	3%	5%	-8%	5%	10%	-8%	5%	15%	-8%
2017	3%	5%	23%	5%	10%	23%	8%	15%	23%
2018	2%	5%	6%	5%	10%	2%	7%	15%	2%
2019	2%	5%	2%	4%	10%	2%	6%	15%	2%
2020	2%	5%	2%	4%	10%	2%	5%	15%	2%
2021	2%	5%	10%	3%	10%	5%	5%	14%	1%
2022	2%	5%	2%	3%	10%	2%	5%	13%	2%
2023	2%	5%	2%	3%	10%	2%	5%	12%	2%
2024	1%	5%	9%	3%	10%	2%	4%	11%	2%
2025	1%	5%	2%	3%	10%	2%	4%	10%	2%
2026	1%	5%	2%	3%	10%	2%	4%	10%	0%
2027	1%	5%	11%	3%	10%	2%	4%	10%	3%
2028	1%	5%	2%	3%	10%	3%	4%	10%	3%
2029	1%	5%	2%	3%	10%	3%	4%	10%	3%
2030	1%	5%	2%	2%	10%	3%	4%	10%	3%

Source: Author's Econometric Analysis

Figure 22. Diesel oil demand curve from 1978 to 2014 (historic values) and long-term forecast until 2030 based on alternative scenarios (Linear model).



Source: Author's Econometric Analysis

Table 15. Forecast of Diesel oil Demand in natural logarithms until 2030 on 3 alternative scenarios.

YEAR	UNDER PERFORMANCE SCENARIO (Ln)	REFERENCE SCENARIO (Ln)	OVER PERFORMANCE SCENARIO (Ln)
2014	5.34	5.34	5.34
2015	5.42	5.44	5.45
2016	5.48	5.53	5.57
2017	5.45	5.53	5.6
2018	5.47	5.59	5.69
2019	5.49	5.65	5.78
2020	5.52	5.71	5.86
2021	5.52	5.75	5.94
2022	5.54	5.8	6.01
2023	5.56	5.85	6.07
2024	5.57	5.9	6.13
2025	5.59	5.95	6.19
2026	5.61	6.00	6.25
2027	5.6	6.04	6.31
2028	5.63	6.09	6.36
2029	5.65	6.14	6.41
2030	5.67	6.18	6.46

Source: Author's Econometric Analysis

Table 16. Forecast of Diesel oil Demand in thousand tons until 2030 on 3 alternative scenarios.

YEAR	UNDER PERFORMANCE SCENARIO (kT)	REFERENCE SCENARIO (kT)	OVER PERFORMANCE SCENARIO (kT)
2014	2,317	2,317	2,317
2015	2,505	2,552	2,596
2016	2,660	2,794	2,893
2017	2,571	2,789	2,986
2018	2,604	2,961	3,259
2019	2,670	3,125	3,543
2020	2,732	3,300	3,837
2021	2,721	3,429	4,144
2022	2,782	3,596	4,437
2023	2,842	3,770	4,726
2024	2,838	3,954	5,013
2025	2,897	4,143	5,288
2026	2,955	4,339	5,611
2027	2,931	4,546	5,912
2028	2,989	4,760	6,221
2029	3,048	4,983	6,541
2030	3,107	5,188	6,870

Source: Author's Econometric Analysis

Table 17. Forecast of Diesel oil Demand annual change until 2030 on 3 alternative scenarios.

YEAR	UNDER PERFORMANCE SCENARIO (kT)	REFERENCE SCENARIO (kT)	OVER PERFORMANCE SCENARIO (kT)
2014			
2015	8%	10%	12%
2016	6%	10%	1%
2017	-3%	0%	3%
2018	1%	6%	9%
2019	3%	6%	9%
2020	2%	6%	8%
2021	0%	4%	8%
2022	2%	5%	7%
2023	2%	5%	7%
2024	0%	5%	6%
2025	2%	5%	5%
2026	2%	5%	6%
2027	-1%	5%	5%
2028	2%	5%	5%
2029	2%	5%	5%
2030	2%	4%	5%

Source: Author's Econometric Analysis

Naturally, there are significant differences between the three alternative scenarios we have been elaborating on. As a general remark, in the less optimistic scenario (under performance) the diesel demand will grow approx. 34% by 2030, in the reference scenario 224% whereas in the more optimistic one 297%.

3.3.2 Biodiesel Demand

In the second and last part of our forecasting process we aim to apply alternative policy scenarios regarding the biodiesel blending rate on diesel demand projections so as to outline the biodiesel demand potential in Greece for the next 15 years.

As aforementioned the current blending rate – valid from 2013 – has been regulated at 7%. This blended fuel is also called B7. Thereafter, the 7% blending rate will be our base case scenario. Beyond this though, as analyzed with much detail in the very comprehensive report of Delft University "Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits"[155],

[155] Kampman, B. et al, (2013), Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits, CE Delft, p. 111, The Hague, Netherlands

which was commissioned by the European Commission, DG Energy, with reference to biofuels potential, “there is an almost unlimited number of options. Each one of the options have specific advantages with respect to vehicle costs, fuel costs or infrastructure costs. Developing all the options at the same time would place an unacceptable burden on vehicle development & production and infrastructure development & operation.”

The results of the overall assessment the study team performed for biofuels in the EU are summarized in the following tables 17 and 18, which for the purposes of this essay have been limited to diesel and biodiesel (FAME) related scenarios. According to the authors, the most probable blending rate to adopt would be 10%, with diesel fuel B10. While there are few more advanced scenarios suggesting 20 and 30% blending rates respectively (B20 and B30). While we share the perspective of the 10% scenario being the most probable development in terms of feasibility in Greece, with the least technical and economic constraints to overcome, a blending rate over 15% seems unlikely even as a mere possibility. Given the fact that the biodiesel production in Greece is mainly energy crop based and a 7% cap on renewable energy for road transport deriving from energy crops has been legislated, the biodiesel blending rate, without any significant restructuring of the market, could rise up to 15% approximately (substituting the share of the non-existing bioethanol as analyzed in §2.2.3 Swot Analysis/Opportunities). Concluding, our three alternative scenarios will be composed of the base case ratio 7%, the most probable case ratio 10% and the maximum case ratio 15%.

Table 18. Overview of the assessment of biodiesel blending options, taking expected physical limitations into account. All data for 2020, EU-average

		Max. vehicle availability (share of fleet)	**Cost (vehicles)**	**Cost (fuels)**	**Need for protection grade?**
Increase blending limits for large share of vehicles					
2	Blending limit for diesel from B7 to B10	Cars: 20% HDV: 85%	Cars: low/medium trucks: low	Low	Yes
2A	Blending limit for diesel from B7 to B10 (15% cars in 2012)	Cars: 20%	Low/medium	Low	Yes
2B	Blending limit for diesel from B7 to B10 (HDV 85% in 2012)	HDV: 85%	Low	Low	Maybe not
8	25% market share of B30 for trucks	Trucks and busses: 25%	Low	Low	N.a.
9	10% market share of B100 for trucks	Trucks and busses: 10%	Medium	Low	N.a.
Increase biofuels use in non-road modes					
15	Increased use of B20 in inland shipping (10%)	50%	Low	Low	Yes
16	Increased use of B20 in trains (10%)	100%	Low	Low	Yes

Source: Kampman, B. et al, (2013), Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits, CE Delft, p. 112 - 113, The Hague, Netherlands

Table 19. Overview of the assessment of biodiesel blending options, taking expected physical limitations into account. All data for 2020, EU-average

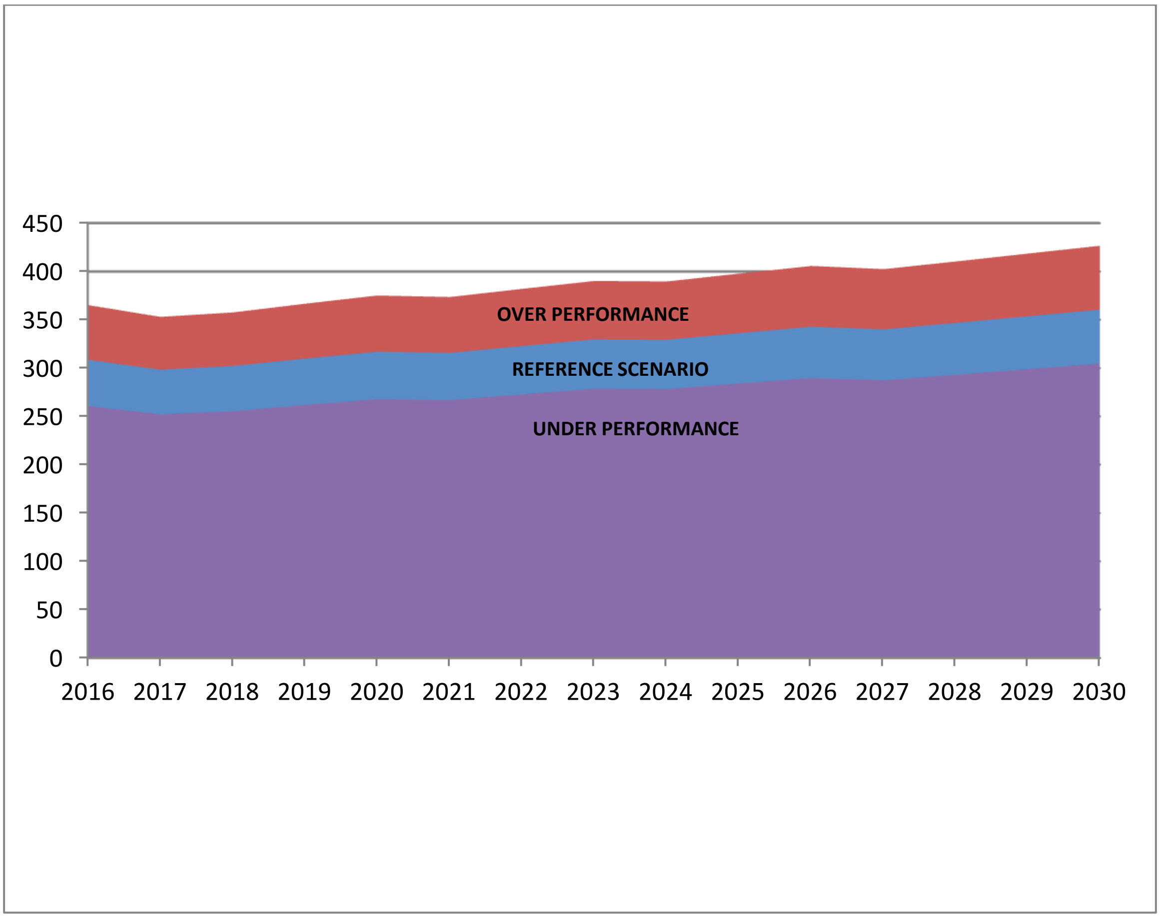
		Marketing issues (consumers)	Potential for further decarbonisation (post-2020)	Main constraints	EU policy efforts needed
	Increase blending limits for large share of vehicles				
2	Blending limit for diesel from B7 to B10 (15% cars, HDV 40%)	Consumers may prefer B7 Price advantage B10 recommended	Technical: +	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation (HD probably earlier than cars)
2A	Blending limit for diesel from B7 to B10 (15% cars)	Consumers may prefer B7 Price advantage B10 recommended	Technical: o	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation
2B	Blending limit for diesel from B7 to B10 (HDV 40%)	Consumers may prefer B7 Price advantage B10 recommended	Technical: +	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation
	High blends in niches (captive fleets)				
8	25% market share of B30 for trucks	Users may prefer standard diesel B7 or B10. Price advantage B30 recommended (on energy basis).	Technical: +	Availability of sustainable feedstock, consumer demand (incl. cost and environmental perception), sufficient number of type approval Euro VI and Euro VII B30 trucks	Coordinate agreement with vehicle and oil industry about vehicle availability and fuel price compared to other fuels, decide on ILUC
9	10% market share of B100 for trucks	Price of B100 should be lower of comparable to standard diesel. Uncertainty about fuel flexibility (B100 & B10 compatible)	Technical: o	Availability of sustainable feedstock, consumer demand (incl. cost and environmental perception), sufficient number of type approval Euro VI and Euro VII B100 trucks	Coordinate agreement with vehicle and oil industry about vehicle and fuel availability and fuel price compared to other fuels, decide on ILUC
	Increase biofuels use in non-road modes				
15	Increased use of B20 in inland shipping (10%)	Hesitation with biocomponents and associated operational risks. Fuel price must be competitive on MJ basis.	Technical: +	Availability of sustainable feedstock, consumer demand (i.e. cost and environmental perception), technical issues with storage and auxiliary systems	Decide on ILUC Organize competitive price for B20
16	Increased use of B20 in trains (10%)	Not very positive image. Fuel price must be competitive on MJ basis.	Technical: +	Availability of sustainable feedstock, consumer demand (i.e. cost and environmental perception), technical issues with storage and auxiliary systems	Decide on ILUC Organize competitive price for B20

Source: Kampman, B. et al, (2013), Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits, CE Delft, p. 114 - 115, The Hague, Netherlands

At the base case the 7% ratio is obviously maintained up to 2030, whereas at the most probable case, we assume that the 10% ratio is adopted from 2018 onwards. We know for fact that the blending ratio is not going to change for 2016[156] and we assume the same for 2017, as no formal initiatives have been made public yet. Respectively, at the maximum case ratio, we assume that before adopting the 15% ratio, there will be an adjustment period of 10% ratio between 2018 and 2020.

The aforementioned rationale of the alternative biodiesel policy scenarios is then applied to the three alternative diesel demand projections, i.e. at the under-performance scenario, the reference and the over-performance one, creating the following results:

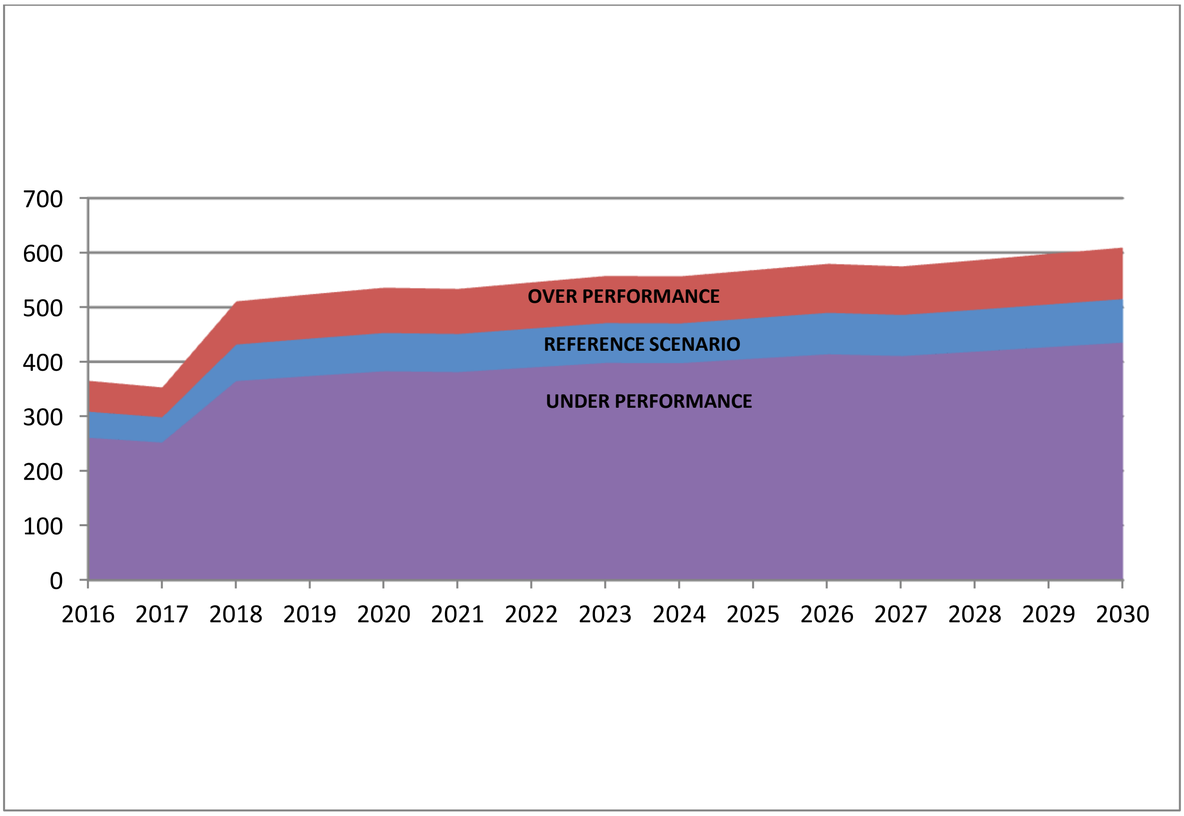
Figure 23. Forecast of base case blending ratio 7%. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



<u>Source</u>: Author's Econometric Analysis

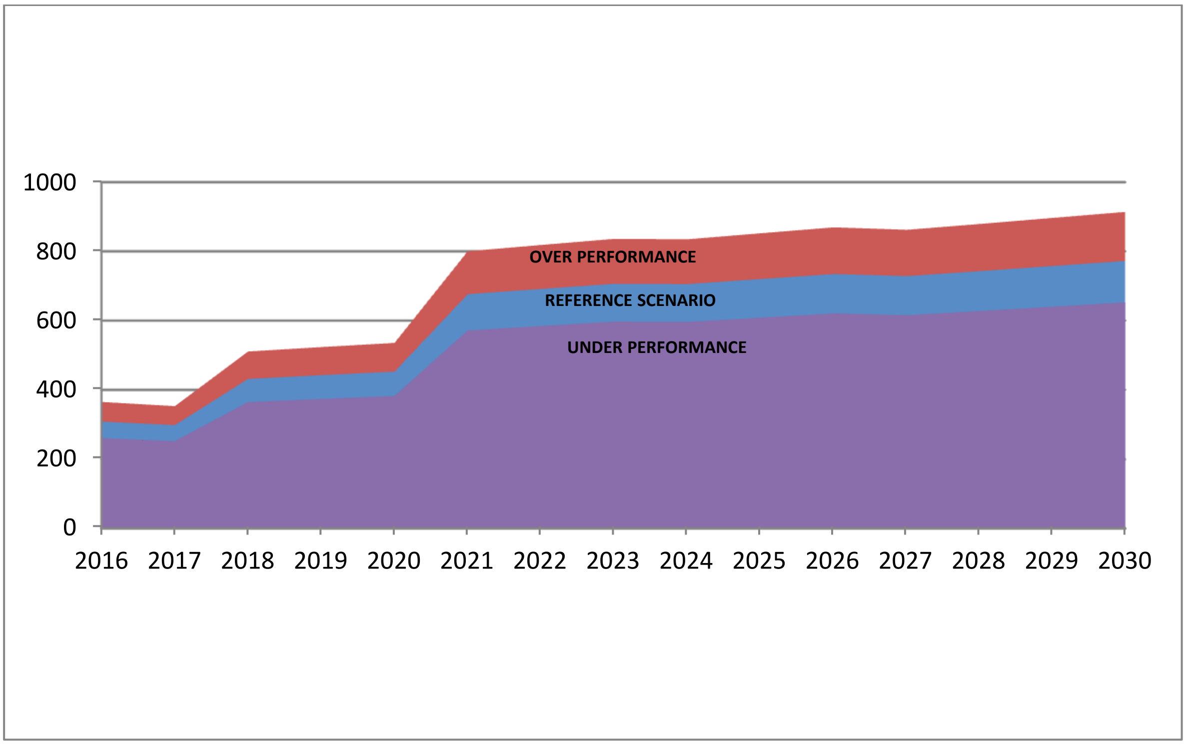
[156] Ministerial Decision 177451, (2016), Biodiesel allocation for 2016 according to the provisions of the article 15A of Law 3054/2002, Hellenic Republic, FEK 1417 (19/5/2016)

Figure 24. Forecast of most probable case blending ratio 10%. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



Source: Author's Econometric Analysis

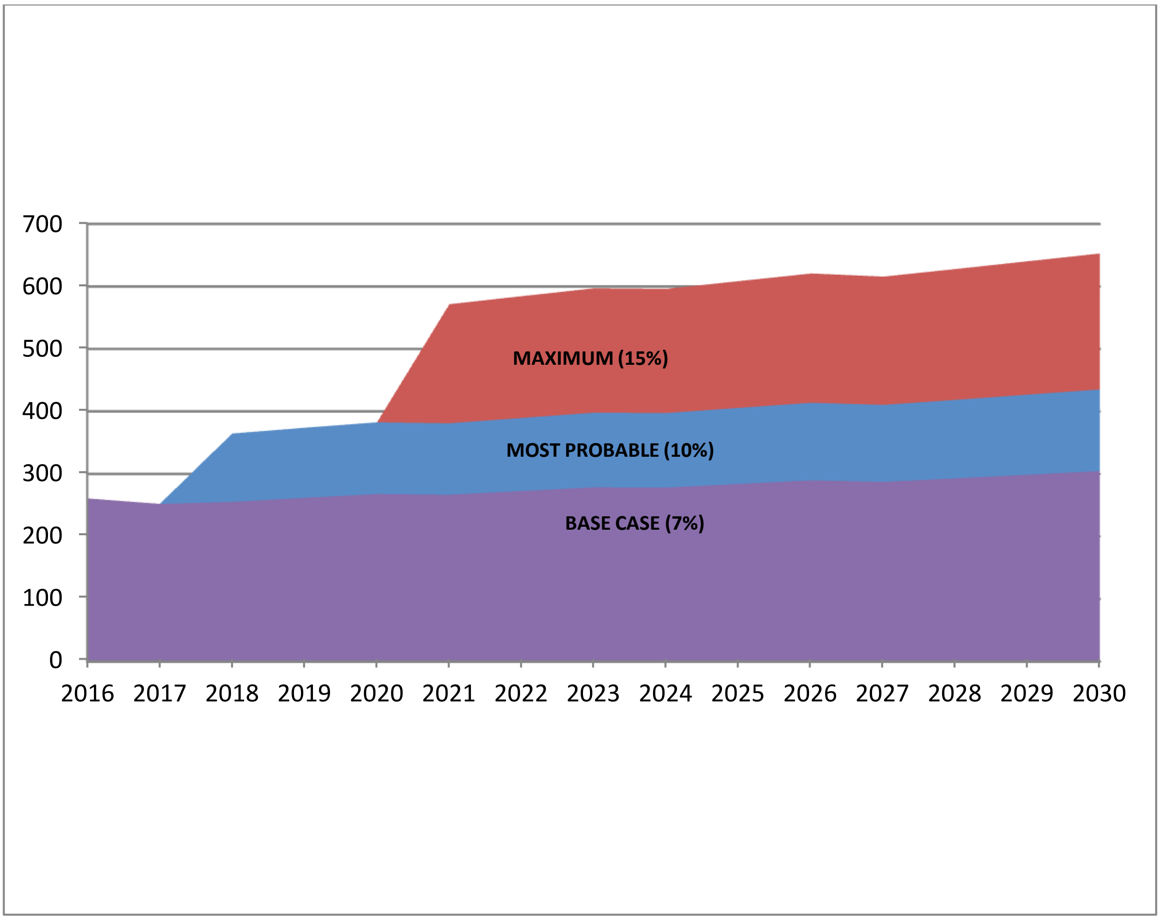
Figure 25. Forecast of maximum case blending ratio 15%. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



Source: Author's Econometric Analysis

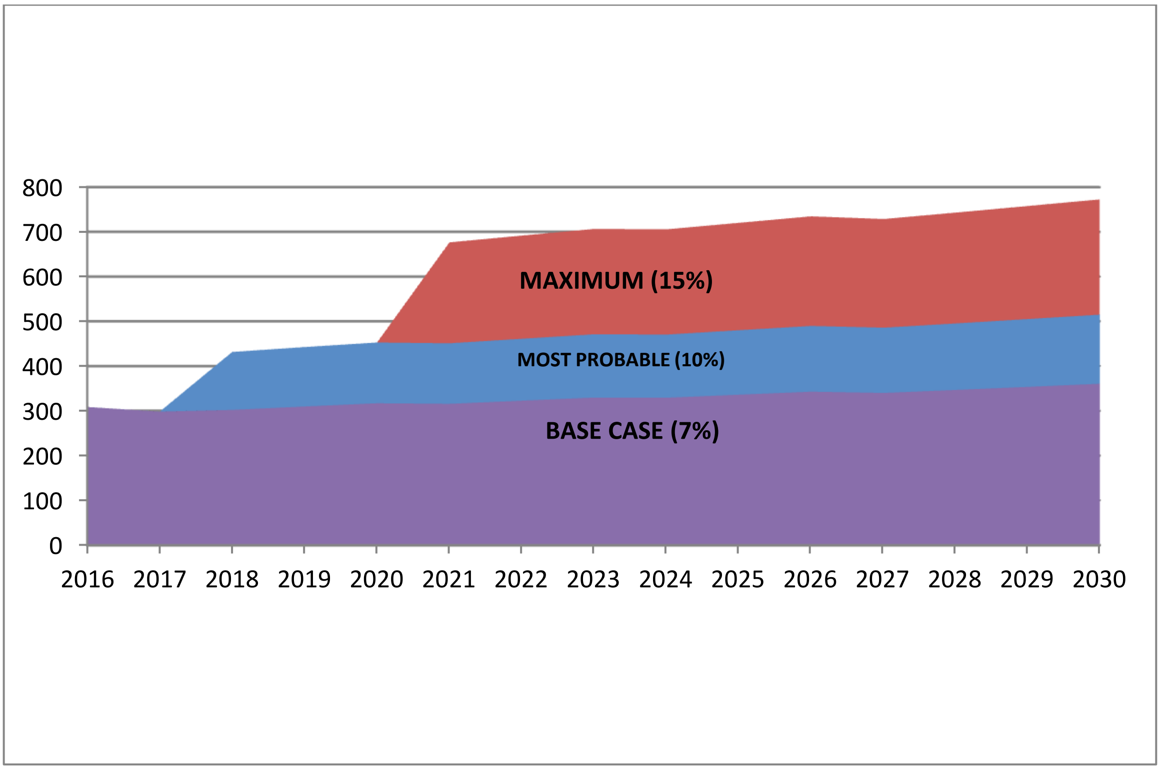
In the previous diagrams, we have illustrated each biodiesel blending ratio case versus the three alternative performance scenarios of the diesel demand. The vice versa illustration is also of interest, i.e. each diesel demand performance scenario versus the three alternative blending ratio cases.

Figure 26. Forecast of the biodiesel demand at the under-performance diesel demand scenario. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



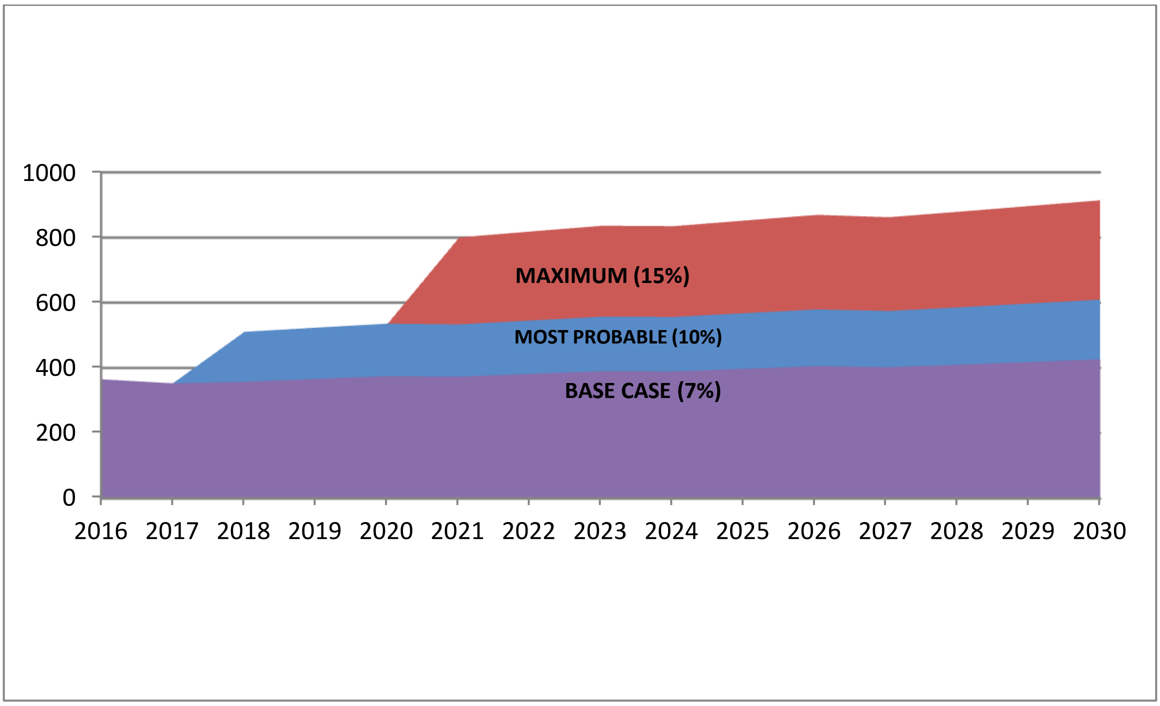
<u>**Source**</u>: Author's Econometric Analysis

Figure 27. Forecast of the biodiesel demand at the reference performance diesel demand scenario. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



Source: Author's Econometric Analysis

Figure 28. Forecast of the biodiesel demand at the over-performance diesel demand scenario. Values of vertical axis are the projected biodiesel demand volumes in thousand cubic meters or million liters.



Source: Author's Econometric Analysis

Chapter 4: Conclusions

The aim of this final chapter is to highlight the main topics examined throughout the dissertation, draw key conclusions out of them where possible and formulate proposals for further elaboration and research related to the biofuels' prospects globally and locally.

Mankind has been using the renewable energy of biofuels since its dawn. Of course, a large scale utilization of them has been taking place over the last hundred years. Rudolf Diesel, inventor of the diesel engine, originally designed it to run on vegetable oil. One of his early demonstrations, at the World Exhibition in Paris in 1897, had a diesel engine running on peanut oil. Similarly, Henry Ford had designed his innovative car Model T to run on ethanol. He envisaged a world running on biofuels: "The fuel of the future is going to come from fruit like that sumac out by the road, or from apples, weeds, sawdust – almost anything". However, the era of great industrialization of biofuels, like the one of the other renewable energy sources, only began in the 1970s as the aftermath of the two great oil crises and the early environmental concerns. Dramatic improvements in technology, favorable policy frameworks, powerful ecological culture and high oil prices were the main reasons that pushed the commercialization of biofuels since the 1990s way ahead until nowadays. For the past 25 years, their worldwide penetration has been blossoming and kept having improved outlook. Nevertheless, the biofuels' growth rates now seem to be facing severe challenges, driven by the competition from other renewables, lower oil prices, concerns about improper land use, controversy about their sustainability and turbulent policy reviews that spread uncertainty in the market.

Although the discussion about the classification of biofuels among researchers and scholars has not ended, there is at least the consensus that biofuels are divided into two generations and possibly a third one. The first generation includes the three most common types of biofuels worldwide, biodiesel, bioethanol and biogas. The second generation of biofuels is more technologically advanced and is considered a lot more sustainable. In contrast to the first generation, where biofuels are basically produced from the edible parts of plants, the second generation focuses on lignocellulosic material which is actually the majority of the cheap and abundant nonfood materials available from plants. Despite their rapid evolution in terms of technological improvements that decrease production costs, the second generation biofuels are still considered expensive and therefore have limited penetration globally. The third generation are the algal biofuels. The term "algae" refers to a great diversity of organisms – from microscopic cyanobacteria to giant kelp. Most algae convert sunlight into energy in a similar manner as plants. However, the genetic diversity of the many different kinds of algae gives researchers an incredible number of unique properties that can be harnessed to develop promising algal biofuel technologies.[157]

Regarding their contribution to the society, economy and environment, as it is common with many innovations and trends, there has been a long standing debate. Due to their complexity, the issue of the issue of biofuels pros and cons should be addressed both locally and globally and of course in the short and long term. Arguments in favor of biofuels support that they are renewable fuels and actually they still are the best by far substitute for liquid fuels, thus the best renewable energy source for all kinds of transportation. Furthermore, due to their renewability and availability, biofuels may help decrease each country's dependence on oil products and therefore its energy security. They also contribute significantly to the development of rural economy, by creating new business for the agricultural sector and providing robust income to farmers. On the other hand, arguments questioning the real contribution of biofuels are mainly targeted on their renewability and sustainability degree, since vast areas of land are committed to the production of energy crops and greenhouse gases do get emitted through their heavy logistics chain. They also pose threats on food supply and biodiversity.

Global energy needs will continue to grow as prosperity around the world increases. Renewables were estimated to hold a market share of 2% in 2014 which is expected to rise up to 7% by 2035, being the only type of energy that is going to increase its market share. It is worth noticing though, that due to the unprecedented technological evolution, since the early 1980s the energy consumption growth rate is gradually decoupling from the GDP growth rate. In transportation in particular, the current energy efficiency of vehicles is expected to be increasing by 2% annually until 2035. Regarding biofuels specifically, after a period of rapid growth, during which biofuels built a share of 3.8% of global road transport energy consumption in 2014, it seems that their expansion is shifting gears. Their market share estimation is 4% by 2020. Currently, biofuels globally are dominated by bioethanol with an 80% market share in 2010 and 20% for biodiesel. The projection of 2030 predicts that the bioethanol share will fall to 71%, the biodiesel will also fall to 12%, but BTL (biomass to liquids) will emerge and stand to 12% market share, especially due to second and third generation biofuels.

Policy and regulatory frameworks have played a key role in the creation of a large biofuels market worldwide (22.5 billion liters of biodiesel and 83.1 billion liters of bioethanol by 2012). The majority of developed and developing countries have been following specific policy mixtures for biofuels. Most of them have implemented a combination of blending mandates with fossil fuels, tax incentives and government subsidies. Of course, these policy combinations have not been permanent. In their

[157] U.S. Department of Energy, (2016), Algal Biofuels, Office of Energy Efficiency & Renewable Energy, http://energy.gov/eere/bioenergy/algal-biofuels, Washington DC, USA

beginning, the state intervention was more emphatic and gradually headed to deregulation. Yet, all the countries that we studied (BRICS, ASEAN-6, USA, European Union, Greece), with the exception of Russia, still adopt state measures that promote the use of biofuels and/or rules mandating such use (Russia never had biofuels policies in place and perhaps this is why biofuels there are practically non-existent). Greece, being a member state of the European Union, has been closely adopting the EU legislation and regulations with limited differentiations where and if it is allowed and requested. In the scope of Directive 2009/28/EC, Greece elaborated and submitted its National Renewable Energy Action Plan in June 2010, according to which, the national target for the contribution of renewable energy sources in the final consumption of energy in the transport sector, has been set to reach at least 10% by year 2020. The Plan also prescribes that biofuels and especially the domestically produced biodiesel will lead towards to the achievement of the 10% target in the transportation sector. The actual blending of biodiesel with diesel began in Greece at the end of 2005 at a rate of 2.5% and is now regulated at 7%. A Biodiesel Allocation Program has been in place, which each year, determines the amount of biodiesel to be allocated for domestic production and imports. The beneficiaries of the allocation are primarily the domestic producers and secondarily the two local refineries and few local petroleum products marketing companies that have been admitted in the beneficiaries' list. Following a complex calculation system, the allocation quantity per beneficiary is determined and of course is obligatory to comply with for any party that wishes to blend diesel with biodiesel in Greece. It is evident, that this system is restrictive for all stakeholders namely producers, refiners, blenders or marketers, creates entry barriers and promotes greatly the domestic agricultural and biodiesel production.

Due to the fact that the biofuel industry is not currently maintaining its recent dynamic on a global scale, researchers have started suggesting that biofuels should leave the promptest the once efficient state aided policies and be reinvented by applying marketing strategies as any other product. Sustainability, being the zeitgeist of our times, can be accredited to biofuels with great success, as they are renewable, cleaner, considered to harm the environment much less than fossil fuels and overall quite satisfactory in terms of transportation efficiency. Furthermore, the application of a comprehensive 4 Ps marketing methodology – product classification, pricing, place, promotion – is expected to add extra value to biofuels. Moreover, new important opportunities, apart from the traditional road transportation sector which almost engrosses the production of biofuels worldwide, such as biofuels in the aviation and the marine sector are emerging.

Regarding the pricing of biofuels, no overall rules can be easily determined as they depend on a complex mixture of factors that are often affected from and influence each other such as: biofuel type, costs of various types of feedstock, production volume, production process, tax and other incentives, food prices, transportation costs, research investment, technological generation, business targeted margins and more. In general, most enterprises and countries intend to hold the end price ("price at the pump") of biofuels at or near the price of petroleum fuels.

The food versus fuel debate, i.e. the dilemma regarding the risk of diverting farmland or crops for biofuels production to the detriment of the food supply which has been a long standing and controversial throughout the literature, has triggered many researchers to study the existence of price transmissions or spill-over effects between oil, petroleum products, coal, natural gas, feedstock for biofuels, biofuels, food commodities, exchange rates etc. The majority of these econometric studies agree that there are such effects and one should not overlook the introduction of new sources of risk, as the market prices of agricultural commodities may become more dependent on fossil energy prices. Therefore, biofuel policies should be closely monitored and probably altered in order to save resources from unnecessary first generation biofuels subsidization. We should also bear in mind that the threat of sudden and unanticipated rises in oil prices, which will consequently lead to rises in food prices, cannot be avoided, unless we substitute part of our oil based energy needs with alternative fuels.

Looking over biofuel global trading practices and risk management status, we conclude that since their large scale industrialized history is rather short, their trading compared with other commodities lacks contract standardization and liquidity, which results in absence of full commoditization. Of course, this situation is changing rapidly and it is worth noting that the two most significant information providers for the commodities and energy markets, Platts and Argus Media are providing daily price assessments on various products of biofuels on a global level as well as on their potentially hedging commodities such biodiesel "paper" products, agricultural commodities, freight and so on. As price correlations between agricultural, biofuel and oil products do exist, the value of these financial hedging tools will be increasing, likewise with the majority of financial products, as the liquidity of the commodity markets increases too.

With reference to the Greek market of biofuels, the term of liquid biofuels in Greece is practically identical to the one of biodiesel as neither bioethanol production locally nor any bioethanol imports have been performed. Despite the fact that the European legislation and regulatory framework regarding bioethanol are present, no targeted policies aiming to promote the production, import and consumption of bioethanol have taken place. The Greek biodiesel journey began naturally at a research level firstly in 1995, with the National Technical University of Athens and Elinoil S.A., later parent company of Elin Biofuels S.A. being the key contributors of this systematic effort. The company Hellenic Biopetroleum S.A. was the first to produce biodiesel commercial volume output in December 2005. In 2015, among the 18 companies which qualified as beneficiaries of the annual volume, 12 were producers and 6 importers. The 12 producers accumulated in total for the 93% of the volume, for approx. 130 thousand cubic meters (i.e. one hundred thirty million liters). However, their installed capacity is approximately sevenfold the total annual volume. Thus, one can easily conclude that the domestic production capacity is largely underutilized. The PESTEL and SWOT analytical frameworks have engineered our macroeconomic and microeconomic environment analysis which has been enriched with the results of the qualitative questionnaire which included four areas of interest – Current production technology and perspective, Current biofuels portfolio and perspective, Current market performance and perspective, Road to 2020 we addressed to four major biofuel corporations in Greece (AGROINVEST S.A., PAVLOS N. PETTAS S.A., GF ENERGY S.A. ELIN BIOFUELS S.A.). The conclusions of the Greek macro and micro environment analysis are numerous and can be found in paragraphs 2.2.2 and 2.2.3. Without understating the significance and special value of each conclusion, we will be citing hereunder a few opportunities and threats of key importance:

- In the pursuit of the 2020 target of 10% substitution of energy for transportation by renewable energy sources and adhering in parallel to the 7% cap on crop based biofuels, the overall yearly biodiesel allocation could increase by at least 200%, doubling and more the current blending rate – from 7% to 15%, without changing the current market structurally, but meeting other conditions such as new blending standards, feasibility approvals etc.
- The import and production of bioethanol is totally a new ground for business, which under certain circumstances could potentially lead to a bioethanol market amounting to 140 thousand cubic meters per year which is exactly the size of the Greek biodiesel market (140 thousand cubic meters in 2015).
- The blending of biodiesel with heating gas oil for industrial and residential heating purposes and the usage of blended diesel for power generation (only for the diesel fueled power plants obviously) could boost the market by 20% annually.
- The implementation of the double counting scheme in Greece like in other EU countries would add value to the sector quickly and work in convergence with the applied national strategy.
- Marginal lands which in general are of poor quality with regard to agricultural use could possibly be used for biomass production.
- Given the absence of established bioethanol blending in Greece, the achievement of national targets until the very close horizon of 2020 remains doubtful.
- While achieving the 2020 targets seems dubious, there has been no sign of updated national planning beyond 2020 until nowadays.
- Just in eight years, four major legal acts have been introduced, the one amending the other, accompanied by numerous ministerial decisions, technical standards

and customs provisions – the frequently changing institutional framework is wounding the industry.

- High relative costs limit the sustainability and question the viability of the industry. The relatively high cost of feedstock in Greece is considered to be the most material factor for the high price of the final product. If it were not for the biodiesel allocation program that regulates in total the produced and traded quantities and thus the prices, giving by far priority to domestic production (for instance in 2015, 93% domestic and 7% imports), there is a possibility that extensive low cost imports would have flooded the market. In addition, the fact that the Biofuel Producers pay for value added tax (VAT) with their purchases but do not collect VAT from their sales since they sell untaxed product, creates a significant working capital restraint, which is amplified due to the delays at the return of VAT from the Greek State.

In Chapter 3, we applied an empirical econometric analysis of the demand for automotive fuels in Greece, we developed a model so as to estimate their future demand and ended up assessing the potential demand for biofuels according to various possible policy scenarios on the thresholds of 2020 and 2030. Since the only biofuel substituting automotive fuels currently in Greece is biodiesel, our study was naturally focused on the demand of automotive diesel oil and biodiesel. Further research can be brought on the area of gasoline and bioethanol following similar methodology, creating opportunity for further elaboration.

Although the study of the road transport energy demand is not a new area, we believe that our research has added pieces of novelty to the matter since:

- By employing up-to-date historical data (up to 2014 incl.) we largely incorporated the impact of the great economic recession Greece has been suffering since 2009.
- We specifically studied the automotive diesel oil demand which has been more or less "neglected" by the researchers of the local market, capturing as well the recent lifting (November, 2011) of the ban on the movement of vehicles with diesel engines in Attica and Thessaloniki, which has ever since kept transforming the car market.
- We linked the biofuel future demand with results from empirical econometric analysis to possible policy scenarios regarding the biodiesel blending mandates.

Our investigation of the diesel demand showed clearly that the automotive diesel oil demand was increasing as long as the country's GDP was growing, from 1978 until 2008, from 2008 until 2011 it faced a downfall due to the economic crisis and as of 2011 as a result of the diesel ban lifting, started a rampaging increase. After identifying potential deterministic factors of the diesel demand (GDP, Diesel price, Diesel fleet), we thoroughly tested and analyzed them and the interactions between them (stationarity, cointegration, long-term regression, short-term regression) following the methodology of other researchers too and concluded to statistically significant elasticities that may specify the demand of our dependent variable (automotive diesel oil demand).

At the last section of the empirical study, we entered the area of forecasting with two approaches, the short-term and long-term one. We initially tried to project the short term – up to 2020 – diesel demand and therefore the related biodiesel demand, only with the help of the ARIMA methodology, i.e. without trying separately to predict the evolution of the demand deterministic factors. The results showed that compared to 2014, the diesel oil demand and subsequently the biodiesel demand will increase 20% by 2020. At the second approach, this extended up to 2030, we applied the methodology of simple linear models. Naturally, we used the model we had previously specified. The great challenge of this approach is that in order to produce any results, one has to prescribe the evolution of the deterministic variables. Due to the uncertainty degree of such approaches, we applied a sensitivity analysis, formulating three possible scenarios, the reference scenario, the under-performance scenario and the over-performance scenario. The results were that by 2030, in the worst case the diesel demand will grow approximately by one third, in the basic it will double and in the best case it will triple. It is worth noting that even at the worst case scenario, with the lowest GDP growth rates, the highest diesel oil prices and the highest taxation rates (which contribute significantly to the final diesel price), a significant diesel demand growth rate is expected, that ought not to be overlooked by the market stakeholders. Finally and after forecasting the diesel oil demand evolution, we attempt to project the relevant biodiesel demand with reference to alternative policy scenarios about the biodiesel blending ratio mandate. In this case we identify three alternative blending ratios, the base case being the current one (7%), the most probable (10%) being derived from a comprehensive total review of the EU Biofuels market commissioned by the DG Energy and the maximum (15%) being a combination of the latter review's alternative case and the maximum allowed blending ratio according to the 7% cap on renewable energy for road transport deriving from energy crops and the current biodiesel market structure of Greece. The results are obviously various, since multiple scenarios have been implemented. Outlining the overall landscape, the combination of the worst performance scenario with the least blending ratio provides a doubling of the 2015 biodiesel market by 2030, i.e. approximately 280,000 thousand liters, whereas the combination of the best performance scenario with the maximum blending ratio, leads to a six fold biodiesel market by 2030, i.e. approximately 900,000 thousand liters.

Epilogue

The target of this dissertation was to bring light onto the current status of biofuels firstly globally and secondly and with greater detail locally. The methodology we attempted to apply was interdisciplinary following the philosophy of the Master Program in “Energy: Strategy, Law & Economics” at the Department of International & European Studies of the University of Piraeus, Greece, in the context of which this study was conducted. It would be much inaccurate to claim that the topic of biofuels has been exhaustively studied, as it is rather complex, continuously changing and in a certain degree controversial. Further studies on the matter could potentially include a different methodology regarding forecasting such as a Monte Carlo approach, an investigation of the second generation (advanced) biofuels in Greece, a deeper analysis of the local market distortions, a thorough research of the bioethanol potential and prospects, an assessment of the biofuels’ potential in Marine fuels and so on.

Hoping that any forthcoming readers will find this study somehow useful, we end up laying emphasis on the fact that its conduction has been a surprisingly enjoyable journey.

Bibliography

Adusumilli, N. & Leidner, A., (2014), The U.S. Biofuel Policy: Review of Economic and Environmental Implications. American Journal of Environmental Protection, vol. 2, Texas, USA

Alfstad, T.,(2008), World Biofuels Study, Scenario analysis of global biofuels markets, p.viii, Brookhaven National Laboratory, prepared for U.S. Department of Energy, Upton NY, USA

Algieri, B., (2014), The influence of biofuels, economic and financial factors on daily returns of commodity futures prices , Energy Policy, Vol. 69, Elsevier, Amsterdam, The Netherlands

Alves, D. and Bueno, R., (2003), Short-run, long-run and cross elasticities of gasoline demand in Brazil, Energy Economics, Vol. 25, p. 191 – 199, Elsevier, Amsterdam, The Netherlands

Apergis, N. and Voliotis, D. (2013), Spillover effects between fossil energy prices and non-energy commodity prices: further evidence from world spot markets, Int. J. Global Energy Issues, Vol. 36, Nos. 5/6

ASTM (2011), ASTM Aviation Fuel Standard Now Specifies Bioderived Components, News Releases, ASTM International, http://www.astmnewsroom.org, Philadelphia, USA

Bakhat, M. et al, (2013), Economic Crisis and Elasticities of Car Fuels: Evidence for Spain, Economics of Energy, ISSN 2172 / 8437, Vigo, Spain

Baltagi, B. and Griffin, M., (1983), Gasoline demand in the OECD – an application of pooling and testing procedures, European Economic Review, Vol. 22, Elsevier, Amsterdam, The Netherlands

Bentley, R.W., (2016), A Brief History of Forecasting Peak Oil, Introduction to Peak Oil, Springer International Publishing, Cham, Switzerland

Bentzen, J., (1994), An empirical analysis of gasoline demand in Denmark using cointegration techniques, Energy Economics Vol. 16, Elsevier, Amsterdam, The Netherlands

Biemans, M., Waarts, Y., Nieto, A., Goba, V., Jones-Walters, L. & Zöckler, C., (2008), Impacts of biofuel production on biodiversity in Europe, ECNC-European Centre for Nature Conservation, Tilburg, the Netherlands

BP (2014), Energy outlook booklet 2035, BP, London, UK

Campbell, A. & Doswald, N., (2009), The impacts of biofuel production on biodiversity: A review of the current literature, UNEP-WCMC, Cambridge, UK

Caesar, B. et al, (2007), Betting on biofuels, The McKinsey Quarterly, McKinsey & Company, New York, USA

Chatfield, C., (2001), Time-Series Forecasting, p. 7, Chapman & Hall/CRC, Florida, USA

Cooke, B. and Robles, M., (2009), Recent Food Price Movements: A Time Series Analysis, IFPRI Discussion Paper, No. 00942, IFPRI, Washington DC, USA

Corpuz, P., (2015), Philippines Biofuels Annual: Philippines Biofuels Situation and Outlook, USDA Foreign Agricultural Service, Manila, Philipinnes

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009

Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009

Domac, J. et al, (2005), Socio-economic drivers in implementing bioenergy projects, Biomass and Bioenergy, 28(2), p. 97 – 106, Elsevier, Amsterdam, The Netherlands

Dunkerley, F.et al, (2014), Road traffic demand elasticities, A rapid evidence assessment, Rand Europe, Cambridge, UK

Dunkerley, J. and Hoch, I., (1987), Energy for transport in developing countries, Energy Journal, Vol. 8, No. 3, International Association for Energy Economics, Ohio, USA

EBTP (2015), Biofuels for Air Transport: Biofuels in Aviation - An Overview, European Biofuels Technology Platform, http://biofuelstp.eu/aviation-biofuels.html, EU

Edeseyi, M. E. et al, (2015), Rethinking sustainable biofuel marketing to titivate Commercial interests, Renewable and Sustainable Reviews, Vol. 52, Elsevier, Amsterdam, The Netherlands

Eickhout, B., van den Born, G.J., Notenboom, J., van Oorschot, M., Ros, J.P.M., van Vuuren, D.P. & Westhoek, H.J., (2008), Local and global consequences of the EU renewable directive for biofuels. Testing the sustainability criteria. MNP report.

Engle, R. and Granger, C., (1987), Cointegration and error correction: representation, estimation and testing, Econometrica, Vol. 55, New York, USA

EU Commission (2015), EU-28 Energy datasheets, Energy Statistics, EU Commission, DG ENER, Unit A4, Eurostat

European Biodiesel Board (2015), Press Release: The EU biodiesel industry welcomes the regulations extending the “B99” measures against US biodiesel imports, EBB, Brussels, Belgium

European Bioenergy Networks (2003), Liquid biofuels network: Activity Report, France

European Environment Agency (2013), http://www.eea.europa.eu/data-and-maps/figures/mix-of-energy-crops-200620132008

European Union (2015), A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, Brussels, 25.2.2015 COM, 80 final Energy Union Package Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, Comm. Of Regions and European Investment Bank

EXCISE DUTY TABLES, European Commission (2016), http://ec.europa.eu/taxation_customs/index_en.htm

Exxon Mobil (2015), The outlook for energy: A view to 2040, p. 8, Exxon Mobil Corporation, Texas, USA

Feeney, A., (2009), Renewables Commodity Market: Aspects of EU Biofuels Trading, RenewableEnergyWorld.com

F.E.I.R. (2010), Renewable fuels in Greece: deficits and potential, Foundation for Economic & Industrial Research, Athens, Greece

FEK 911 B (19/05/2015), Allocation of 140.000 thousand litres of pure biodiesel for 2015, according to the provisions of art. 15A par. 7 of Law 3054/2002

Flach, R. et al, (2013), EU Biofuels Annual 2013, USDA Foreign Agricultural Service, The Hague, Netherlands

Flach, R. et al, (2015), EU Biofuels Annual 2015, USDA Foreign Agricultural Service, The Hague, Netherlands

Foundation for economic & industrial research (2010), The sector of renewable fuels in Greece: issues and prospects, p.16, Athens, Greece

Garbacz, C., (1989), Gasoline, diesel and motor-fuel demand in Taiwan. Energy Journal Vol. 10, No. 2, International Association for Energy Economics, Ohio, USA

GBEP (2008), A Review of the Current State of Bioenergy Development in G8 +5 Countries, Rome, Italy

General Directorate of the State General Laboratory (2012), The no. 30/005/795 / 12.20.2012 document of the Directorate of Petrochemicals of the General Directorate of the State General Laboratory

Government of India (2008), National Policy on Biofuels, Ministry of New & Renewable Energy on India, New Delhi, India

Government of South Africa, (2007), Biofuels Industrial Strategy of the Republic of South Africa, Department of Minerals and Energy, p.3-4, Pretoria, South Africa

Guerrero, M., (2013), Spain's Bioethanol Standing Report, USDA Foreign Agricultural Service, p. 10, Madrid, Spain

Hamenlick, C., (2013), Biofuels and Food Security: Risks and opportunities, Ecofys, Chamber of Commerce 30161191, p. 1-2, Utrecht, The Netherlands

HLPE (2013), Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, Italy

Hjalmarsson, E. and Österholm, Pär, (2007), Testing for Cointegration Using the Johansen Methodology when Variables are Near-Integrated, IMF Working Paper, International Monetary Fund, Washington D.C., USA

IEA (2014), Renewable energy medium-term market report 2014, Executive Summary, Market analysis and forecasts to 2020, International National Agency, OECD/IEA, 2014, Paris, France

IRENA (2015), Renewable Energy Target Setting

Jennings (2005), The Case For Ethanol, www.forbes.com

Kampman B. et al, (2013), Bringing biofuels on the market: Options to increase EU biofuels volumes beyond the current blending limits, CE Delft, The Hague, Netherlands

Karppi, I. et al, (2001), SWOT-analysis as a basis for regional strategies, Nordregio (the Nordic Centre for Spatial Development) Working Paper 2001:4, ISSN 1403-2511, Stockholm, Sweden

Kim – Keung Ho, J., (2014), Formulation of a Systemic PEST Analysis for Strategic Analysis, European Academic Research, Vol. 2, Issue 5, Hong Kong, China

Magdoff, A., (2008), The Political Economy and Ecology of Biofuels, Monthly Review: An Independent Socialist Magazine Vol. 60, Issue 03, p. 34 – 35, New York, USA

McRae, R., (1994), Gasoline demand in developing Asian countries, Energy Journal Vol. 15, No. 1, International Association for Energy Economics, Ohio, USA

Medeiros, M. & Froio, L., (2012), Actors, Interests and Strategies of Brazilian Foreign Policy on Biofuels, Brazilian Political Science Review, Sao Paolo, Brazil

Milgrom, P. and Roberts, J., (1996), The LeChatellier Principle, The American Economic Review, Vol. 86, No. 1

Mitkidis, G., (2015), MBA Dissertation: Feasibility of 2nd Generation Biofuels in Greece, p. 39, Hellenic Open University, Patras, Greece

Mulder, P. and de Groot, H.L.F., (2005), Decoupling Economic Growth and Energy Use, p. 21, Tinbergen Institute Discussion Paper, Amsterdam, The Netherlands

Muller, S., Marmion, A., Beerepoot, M., (2011), Renewable Energy, Markets and prospects by region, International National Agency, OECD/IEA, Paris, France

Muran, M., (2014), Russian Federation, Biofuels Annual: Biofuels Sector Update, USDA Foreign Agricultural Service, Moscow, Russia

Naik, S.N. et al (2010), Production of first and second generation biofuels: A comprehensive review, Volume 12, Issue 2, Elsevier, Amsterdam, The Netherlands

National Renewable Energy Plan, (2010), Ministry of environment, energy & climate change, Hellenic Republic, Athens, Greece

Nayyar, P., (2010), The Use of Biodiesel Fuels in the U.S. Marine Industry, Maritime Administration, USA

Nicol, C.J., (2003), Elasticities of demand for gasoline in Canada and the United States, Energy Economics Vol. 25, p. 201 – 214, Elsevier, Amsterdam, The Netherlands

Opdal, O.A. & Hojem, J.F., (2007), Biofuels in ships, ZERO, Oslo, Norway

Osterwald-Lenum, M., (1992), A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics, Oxford Bulletin of Economics and Statistics, vol. 54, Oxford, UK

Pacini, H. et al, (2014), The State of the Biofuels Market: Regulatory, Trade and Development Perspectives, UNCTAD, Geneva, Switzerland

Pacini, H. et al, (2014), The State of Biofuels Market: Regulatory, trade and development perspectives, prepared for the United Nations Conference on Trade and Development, United Nations Publication, New York, USA

Paschalidou, A. et al, (2016), Energy crops for biofuel production or for food? - SWOT analysis (case study: Greece), Renewable Energy, Vol. 93, Elsevier, Amsterdam, The Netherlands

Peattie, K., (2001), Towards Sustainability: The Third Age of Green Marketing, The Marketing Review, Vol. 2, Number 2, p. 129 – 146, Westburn Publishers, Helensburgh, Scotland, UK

Petrou, C. and Pappis, C., (2008), Biofuels: A Survey on Pros and Cons, Energy and Fuels, 23, Piraeus

Polemis, M., (2006), Empirical assessment of the determinants of road energy demand in Greece, Energy Economics, Vol. 28, Elsevier, Amsterdam, The Netherlands

Polemis, M., and Dagoumas, A., (2013), The electricity consumption and economic growth nexus: Evidence from Greece, Energy Policy, Vol. 62, Elsevier, Amsterdam, The Netherlands

Preechajarn et al, (2013), Thailand Biofuels Annual, USDA Foreign Agricultural Service, p.3, Bangkok, Thailand

Prugh, T., (2014), Biofuel Production Declines, Worldwatch Institute, Washington, USA

Rapanos, V., Polemis, M., (2005), Energy demand and environmental taxes: the case of Greece, Energy Policy, Vol. 33, p. 1781 - 1788, Elsevier, Amsterdam, The Netherlands

Ramanathan, R. and Geetha, S., (1998), Gasoline consumption in India: an econometric analysis, Proceedings of the First Asia Pacific Conference on Transportation and the Environment, National University of Singapore, Singapore

Saltelli, A., (2002), Sensitivity analysis for importance assessment, Risk Analysis Journal, Vol. 22, Issue 3, John Wiley & Sons, New York, USA

Scott, R., Junyang, J. & Riedel, M., (2013), People's Republic of China Biofuels Annual 2013, USDA, Foreign Agricultural Service, Beijing, China

Searchinger, T. et al, Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change, Science Vol. 319, Issue 5867, Washington DC, USA

Siddiqui, S. et al, (2016), Determining energy and climate market policy using multiobjective programs with equilibrium constraints, Energy, 94, p. 316 – 325, Elsevier, Amsterdam, The Netherlands

Sombilla, M., (2009), Integranting biofuel and rural renewable energy production in agriculture for poverty reduction in the Greater Mekong Subregion: an overview and strategic framework for biofuels development, Asian Development Bank, Mandaluyong City, Philippines

Sterner, T., (2006), Survey of Transport Fuel Demand Elasticities, The Swedish Environmental Protection Agency, Stockholm, Sweden

Stone, M., (2011), Biofuels: volatility and risk management, World Biofuels Congress, Argus Media, www.argusmedia.com

The Swedish Knowledge Centre for Renewable Transportation Fuels (2015), EU sustainability criteria for biofuels, Göteborg, Sweden

Tsionas, E., (2009), Statistical Packages and their Economic Applications, Excel, SPSS, EViews and Gauss in Economics, Statistics and Econometrics, Athens University of Economics and Business, Athens, Greece

Van Dinh Son Tho, (2014), Current statute of biofuel production in Vietnam, School of Chemical Engineering, Hanoi University of Science and Technology, Hanoi, Vietnam

United Nations Framework Convention on Climate Change (2015), Adoption of the Paris Agreement, Framework Convention on Climate Change, Conference of the Parties, 21st session, United Nations, Paris, France

U.S. Department of Energy, (2016), Algal Biofuels, Office of Energy Efficiency & Renewable Energy, http://energy.gov/eere/bioenergy/algal-biofuels, Washington DC, USA

Wright, T. & Rahmanulloh, A., (2015), Indonesia Biofuels Annual, USDA Foreign Agricultural Service, Jakarta, Indonesia

World Energy Council (2010), Biofuels: Policies, Standards and Technologies, World Energy Council, London, United Kingdom, "Used by permission of the World Energy Council, London, www.worldenergy.org"

Worldwatch Institute (2014), F.O. Licht, RENZI

Online Sources

- http://biofuel.org.uk/what-are-biofuels.html
- www.ypeka.gr
- http://www.economicgreenfield.com
- http://www.platts.com/products/market-data-biofuels
- https://www.argusmedia.com/Bioenergy/Argus-Biofuels/
- http://www.iea.org/statistics/onlinedataservice/.
- www.mindtools.com/pages/article/newTMC_09.htm
- https://rapidbi.com/history-of-the-swot-analysis/
- http://www.tradingeconomics.com/greece/indicators
- http://www.tradingeconomics.com/greece/government-debt-to-gdp
- http://www.ifs.du.edu/ifs/frm_CountryProfile.aspx?Country=GR#Population
- http://www.fuelprices.gr/files/EBDOM_DELTIO_08_04_2016.pdf
- http://www.iea.org/statistics/onlinedataservice/.
- http://elinbio.gr/activities#production-process
- http://biofuelstp.eu/sustainability.html
- http://www.seaa.gr/en
- http://www.iea.org/bookshop/661-Energy_Balances_of_OECD_Countries
- http://ec.europa.eu/eurostat/data/database
- http://www.iea.org/statistics/onlinedataservice/
- http://www.platts.com/products/european-marketscan
- http://www.iea.org/bookshop/661-Energy_Balances_of_OECD_Countries
- http://www.ifs.du.edu
- https://data.oecd.org/gdp/gdp-long-term-forecast.htm
- http://www.eia.gov/dnav/pet/pet_pri_spt_s1_w.htm
- http://capitalmind.in/
- http://www.worldbank.org/en/research/commodity-markets

Appendix

Questionnaire for the academic dissertation
"The Greek Biofuel market: trends, prospects and challenges".

University of Piraeus,

Dept. of International and European Studies,

MSc in Energy: Strategy, Law & Economics

1. Production Technology

1.1. Under which generation are the biofuels your plant produces categorized?
1.2. Under the first, second or both?
1.3. If under both, which is the production ratio of each?
1.4. If you only produce first generation biofuels, is your plant ready to move to second generation biofuels?

2. Type of biofuels

2.1. Apart from biodiesel, do you produce any other biofuel?
2.2. Bioethanol is actually nonexistent in Greece. Which do you think are the main reasons behind this lag?
2.3. Which do you think are the most important actions – initiatives that ought to be taken so as the penetration of bioethanol in Greece begins?
2.4. In case the above actions – initiatives happen, are you interested in entering the production and distribution of bioethanol?
2.5. Is your plant capable of technically supporting this new business without realizing critical investments (of over 1 million €)?

3. Biodiesel market

3.1. We notice that the installed capacity of the biodiesel plants of Greece is multiple (up to 9 times) compared to the annual local consumption. Which do you thing are the main causes of this asymmetry?
3.2. Do you agree with the argument that the methodology of the annual biodiesel allocation has now fulfilled its purpose and that we should move to full liberalization of the market?
3.3. What rate of your annual production is exported?
3.4. Which do you think are the 2 greatest opportunities and threats respectively your sector faces?

4. The road to 2020

4.1. Do you believe that the country will be successfully accomplishing the target of the Directive RED (2009) regarding the energy substitution for transport from renewable energy sources at 10% by 2020?
4.2. Do you believe that the imposed cap of 7% on conventional biofuels is an obstacle to the achievement of the target, or anyway, it is impossible to achieve the target with biodiesel only?
4.3. What do you think has to be done in order to accomplish the 10% target?